AD-A130 997 FEASIBILITY OF USING RATIONAL THRESHOLD VALUES TO PREDICT SEDIMENT IMPACT..(U) CONSTRUCTION ENGINEERING RESEARCH LAB (ARMY) CHAMPAIGN IL C C VAUGHN ET AL. JUN 83 CERL-TR-N-153 1/1

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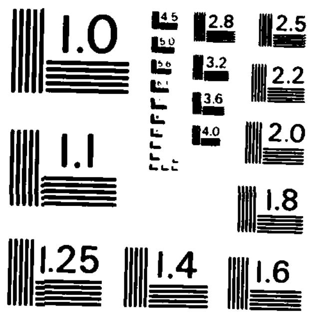

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TECHNICAL REPORT N-153
June 1983
Training Area Environmental Impact Prediction

FEASIBILITY OF USING RATIONAL THRESHOLD VALUES TO PREDICT SEDIMENT IMPACTS FROM ARMY TRAINING

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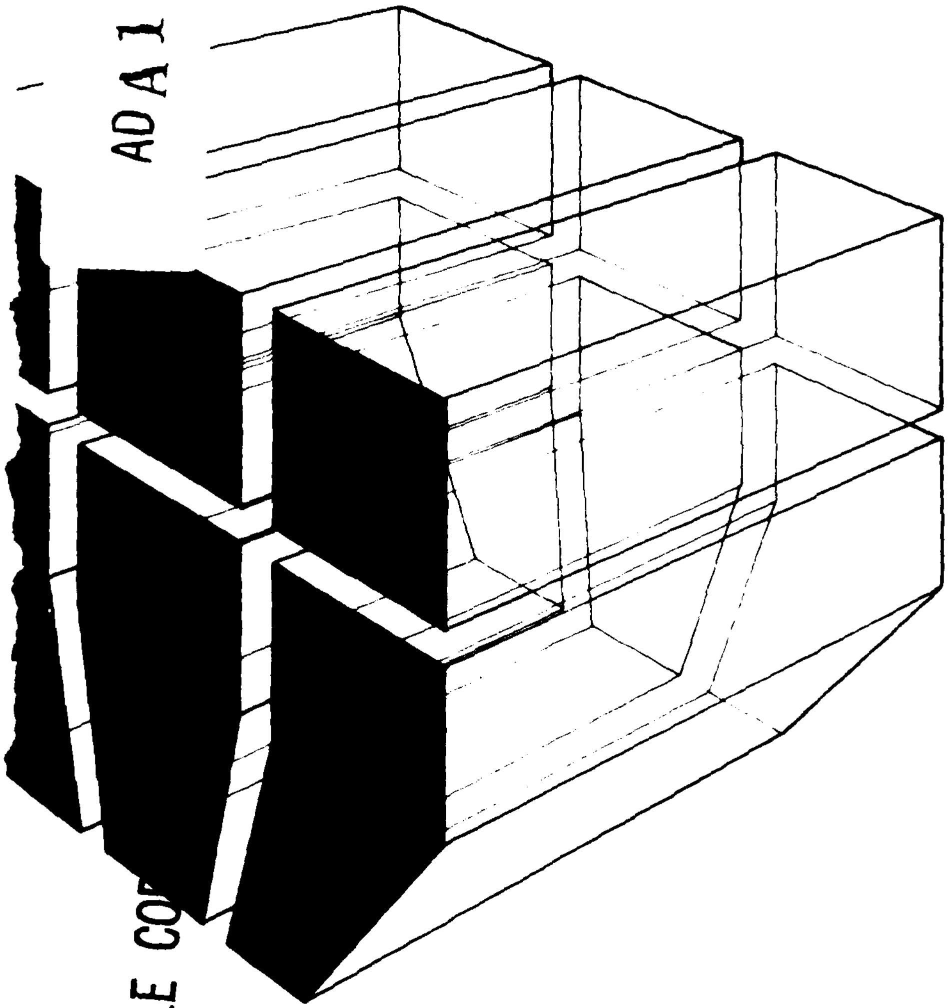

by
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SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER CERL-TR-N-153	2. GOVT ACCESSION NO. AD-A130 997	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) FEASIBILITY OF USING RATIONAL THRESHOLD VALUES TO PREDICT SEDIMENT IMPACTS FROM ARMY TRAINING		5. TYPE OF REPORT & PERIOD COVERED FINAL
		6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) Caryn C. Vaughn Gary D. Schnell Robert E. Riggins		8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS U.S. ARMY CONSTRUCTION ENGINEERING RESEARCH LABORATORY P.O. BOX 4005, CHAMPAIGN, IL 61820		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS 4A762720A896-A-026
11. CONTROLLING OFFICE NAME AND ADDRESS		12. REPORT DATE June 1983
		13. NUMBER OF PAGES 54
14. MONITORING AGENCY NAME & ADDRESS(if different from Controlling Office)		15. SECURITY CLASS. (of this report) Unclassified
		15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

Approved for public release; distribution unlimited.

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

Copies are available from the National Technical Information Service
Springfield, VA 22161

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

aquatic biology
rational threshold values
sediment
training
environmental management

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This report summarizes research on the feasibility of using Rational Threshold Values (RTVs) to predict sediment-related impacts in Army training areas. The information will be useful to Army land managers who program training area maintenance.

The research has indicated that local water quality standards can be used as RTVs if they are based on the aquatic community's response to the physico-chemical and volumetric characteristics of sediment pollution in a specific area. The Relative Algal

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Growth Index, with modifications, can also be used as an RTV for lentic systems. In lotic systems, fish population levels can be used as RTVs for certain fish species if specific criteria are met.

FOREWORD

This study was performed for the Assistant Chief of Engineers under Project 4A762720A896, "Environmental Quality For Construction and Operation of Military Facilities"; Task A, "Installation Environmental Management"; Work Unit 026, "Training Area Environmental Impact Prediction." Mr. Donald Bandel, DAEN-ZCF-B, was the Technical Monitor.

The work was performed by Caryn C. Vaughn and Gary D. Schnell of the Oklahoma Biological Survey, University of Oklahoma, Norman, OK, under Contract No. DACA 88-80-MOD40 for the Environmental Division (EN) of the U.S. Army Construction Engineering Reserach Laboratory (CERL). The assistance of the following University of Oklahoma personnel in producing this report is acknowledged: Frank L. Sonleitner, Alan P. Covich, Thomas M. McKenna, Deborah K. Abernathy, and Diane L. Fields.

Dr. R.K. Jain is Chief of CERL-EN. COL Louis J. Circeo is Commander and Director of CERL, and Dr. L. R. Shaffer is Technical Director.

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FEASIBILITY OF USING RATIONAL THRESHOLD VALUES TO PREDICT SEDIMENT IMPACTS FROM ARMY TRAINING

1 INTRODUCTION

Background

Sediment transported by water is a major cause of degradation to the environment around training ranges and maneuver areas. Sediment becomes a pollutant when it fills reservoirs, lakes, and ponds, clogs stream channels, destroys aquatic habitat, settles on productive land, degrades water quality, increases water treatment costs, damages water distribution systems, and detracts from recreational water use.[1]* Army land managers who program training area maintenance need prediction techniques that include an effective means of indicating sediment-related impacts on the environment. Rational Threshold Values (RTV) quantitative values that can be incorporated into techniques to predict the significance of environmental impacts resulting from military actions -- may be useful for predicting sediment-related impacts.

Objective

The objective of this report is to document the feasibility of using RTVs to predict sediment-related impacts in training areas.

Approach

An extensive survey of previous studies was conducted to determine the effects of sediment on aquatic systems. The effects of sediment on freshwater organisms were summarized (Chapter 2). This information provided a basis for developing potential RTVs for sediment (Chapter 3).

Mode of Technology Transfer

It is recommended that the information in this report be used to develop training area impact prediction techniques. Prediction techniques will be part of a training area maintenance investment program which will be documented in a new technical manual (TM), as well as training area maintenance technologies. The new TM is scheduled for completion in FY86. An interim Engineer Techincal Note on a training area maintenance investment program to control physical degradation will be completed in FY84.

*A key to the references is on p 13. The bibliography (p 15) provides detailed information for each reference.

2 EFFECTS OF SEDIMENT ON FRESHWATER ORGANISMS

Definition of Sediment

The terms suspended solids, sediment, and turbidity are often incorrectly used interchangeably. The term suspended solids is defined as "nonfilterable residue in suspension." It is measured in milligrams of solids per liter (ppm), but is sometimes expressed by measurement of turbidity or light penetration. Sediment is the solid matter component (soil, sand, gravel, and detritus) of suspended solids that has been deposited on the substrate. Synonyms of sediment include alluvium and mud.[2] Turbidity is an optical measurement which describes the degree of opaqueness or alteration of light transmission produced by suspended material and cannot be uniformly equated with concentration.[3]

The organic component (i.e., detritus) of sediment is not considered here, although the organic and inorganic aspects cannot always be easily separated. The literature on the organic component is extensive. Hynes[4] and Wetzel[5] provide discussion and major references on this subject. Further references to sediment, unless otherwise specified, refer to the inorganic component.

Effects on Ecosystems

The concentration of suspended sediment in inland waters is influenced by topography, geology, soil conditions, intensity and duration of rainfall, type and amount of vegetation in the drainage basins, and land use.[6] Lakes, ponds, and reservoirs tend to act as sediment traps.[7] The suspended sediment concentration in most flowing waters varies considerably from day to day, and there may be substantial differences in concentration in different stretches of a stream.[8] Work by Paulet, et al.[9] and Brown[10] provides reviews of sedimentation in lentic* systems.

Sediment alters aquatic environments by screening out light, changing heat radiation, transporting nutrients and toxins, and by blanketing the bottom, causing organic material and other substances to be retained.[11] Suspended sediment scatters and absorbs light, reducing the depth at which effective photosynthesis can occur and altering oxygen relationships.[12] Suspended sediment alters the rate of temperature change in water by absorbing solar radiation so that the

*Inhabiting ponds or swamps.

bottom sediment warms to a lesser extent.[13] In a lentic* system, this may cause or speed up summer stratification.[14]

Adsorption of chemicals by suspended sediment can lead to a buildup of toxic substances in a limited area, especially if a large amount of material is held on the bottom.[15] Erichsen and Kaemmerer[16] and Benoit, et al.[17] described fish kills resulting from such buildups. Toxic substances transport has been reviewed by Sorenson, et al.[18]

Suspended sediment provides a surface for growth of bacteria, fungi, and other microorganisms. Cairns[19] reported that when the presence of particulate matter allows the environment to support much larger populations of these organisms, the dissolved oxygen, pH, and other characteristics of the water are usually changed. Goldman and Kimmel[20] reviewed the literature on the association of microorganisms with suspended sediment particles. They stated that suspended sediment particles can be viewed as exchange surfaces at which both gains (adsorption, colonization, assimilation) and losses (cell lysis, excretion, ingestion, decomposition, leaching) of energy occur continuously, and that such particles constitute a major route of energy flow in lakes and reservoirs.

Sediment absords nutrients, and sediment input may determine the trophic status of an aquatic system.[21] Reviews of sediment-nutrient relationships include Muncy, et al.[22] Sorenson, et al.[23] and Golterman;[24] information on this topic can also be found in any general limnology textbook (for example, Wetzel[25]).

Effects on Algae and Macrophytes

Suspended sediment affects phytoplankton, periphyton, epipelic algae, and macrophyte production. These effects are well documented and easily quantified. Recent references include Edwards,[26] Oschwald,[27] Westlake,[28] Winner,[29] Jones and Bachmann,[30] Stout,[31] and Grobbelaar.[32] Phytoplankton species composition may be influenced indirectly by an altered light regime which changes the water's physico-chemical characteristics.[33] In streams, periphyton and benthic algae can be scoured away by rapidly moving sediment.[34]

Deposition of silt on macrophyte leaves reduces photosynthesis, and some macrophytes may be buried and eliminated by rapid accumulations of silt.[35] Hynes[36] reported that fairly even inputs of sediment in a river can create great stable areas of macrophyte development which can completely alter the substratum and, as a result, the animal population.

Effects on Microinvertebrates and Zooplankton

Although data on the association of microorganisms with suspended sediment are beginning to accumulate,[37] little information is available about sediment effects on non-epipelic forms. If sediment limited primary production because of decreased light transmittance, this would limit the grazing microfauna.[38] In addition, the abrasive action of suspended sediment would be expected to have adverse effects on attached protozoans and micrometazoans.[39] Spoon[40] studied the autwuchs protozoa colonizing artificial substrates in the upper Potomac estuary below a sewage treatment plant. Protozoan abundance increased as turbidity decreased, but as levels of dissolved oxygen, phosphorus, nitrogen, and organic carbons also decreased, the exact role of sediment could not be determined.

The primary impact of sediment on zooplankton is indirect. Increased sediment decreases light; this decreases primary production and therefore food availability.[41] Nutrient regimes altered by silt loads may change species composition either directly or indirectly because of changes in the species composition of the algal food base.[42] Winner[43] observed that filter-feeding cladocerans sank when silt accumulated in their digestive tracts.

Effects on Benthic Macroinvertebrates

Benthic macroinvertebrates usually respond to changes in sediment load by a change in species diversity and/or density. The response in a particular location depends on the existing community's tolerance of and requirements for sediment concentration and particle size distribution. These factors are well documented at the generic level.[44] For example, many stream forms inhabit the interstices between gravel and cobble. Heavy siltation fills in these interstices, eliminating much of this habitat space, and may deplete oxygen in the remaining space.[45] On the other hand, many lentic benthic organisms require fine silt of a certain depth in which to burrow.[46] Prolonged or heavy sedimentation can thus reduce both the total numbers and number of species in an aquatic system and may result in species replacement by forms which are more sediment-tolerant.[47]

Other indirect effects of sediment on benthos which elicit these responses include macrophyte dieoff or increase, and altered food availability.[48]

*Inhabiting ponds or swamps.

Eckblad, et al.[49] reported that increased sedimentation in a river pool allowed *Sagittaria* stands to encroach on the open water. Densities of *Sphaerium* and *Hexagenia* were reduced and subsequently replaced by chronomids, oligochaetes, and gastropods. Allen[50] observed that epipelic diatoms and bluegreen algae in a stream were replaced by filamentous mats when sediment levels increased. This resulted in the replacement of animals adapted to living on exposed surfaces by burrowing and mining forms. Decreases in primary production due to turbidity often reduce macroinvertebrate populations by limiting food.[51]

Sediment may impact benthic populations directly by scouring[52] and smothering.[53] Recent work suggests that drift is a major response of macrobenthos to increased siltation, especially when there are heavy point source inputs.[54]

Suspended sediment can clog bivalve gills, altering pumping and feeding rates, and in some cases causing mortality.[55] Anderson, et al.,[56] described a method for determining LC_{50}'s* for bivalves to sediment.

There is no known information in the literature that describes sediment effects on different larval insect stages, although early instars are probably more susceptible. Davis[57] conducted sediment bioassays using the eggs and larvae of the clam *Mercenaria mercenaria*. Increased sediment concentrations caused increased egg mortality and abnormal embryonic development. Harrison and Farina[58] exposed egg capsules of three species of planorbid snails to varying concentrations of suspended kaolin and sericite and found that cases of abnormal development and mortality increased with increased concentration.

Effects on Fish

Tolerance to suspended and deposited sediment[59] varies among fish species. Some fish are well adapted for life in turbid waters, while others are not.[60] There are many examples in the literature of faunal replacement of silt-intolerant species by silt-tolerant species in aquatic systems following long-term sedimentation and subsequent habitat alteration.[61]

Sediment may impact fish directly by clogging and abrasion of respiratory surfaces, which leads to suffocation, and by smotherings of eggs and larvae. Indirect impacts are more common; they include altering usable habitat and food availability, reducing resistance to disease and parasites, and the effects of sediment-transported toxins and nutrients. The most critical impacts on fish may be those which impair their reproductive processes, adult maturation and reproductive behavior, and egg and larval survival, development, and growth.[62]

Bioassay results indicate that, at normal concentrations, suspended sediment is not acutely lethal to most juvenile and adult fish.[63] Wallen[64] studied 16 species of warmwater fish and noted that most species could withstand concentrations of 20,000 ppm for a week or longer. Fish that succumbed at this concentration showed stress reactions; for example, they floated at the surface and gulped air and displayed reduced fin and opercular movements. When suspended sediment is directly lethal, mortality results from clogged and damaged gill membranes; this reduces ventilation and leads to suffocation.[65] Such mortality is more pronounced in juveniles.[66] Sherk, et al.,[67] maintain that the more pronounced mortality among juveniles for a given concentration of suspended sediment results because they have a higher oxygen demand per unit body weight and because smaller gills have a greater tendency to sieve and entrap suspended particles, thus inhibiting gaseous exchange.

Muncy, et al.,[68] reviewed the effects of suspended sediment and solids on 120 species of warmwater fish. The fish were cataloged for tolerance/intolerance to suspended sediment during the reproductive period, based on their preferred range as observed in the field. Species which were relatively tolerant were found to be simple spawners, which are defined as: (1) exhibiting little sexual dimorphism in color or distinguishing physical characteristics; (2) not defending territories; (3) not preparing nests; (4) having no behavioral courtship; (5) often spawning at night; and (6) not having parental care. Visual stimuli were not important to the reproductive activities of sediment-tolerant fish (e.g., the carp). However, visual stimuli were important to intolerant species, such as the largemouth bass. These species defended territories, exhibited sexual dimorphism, spawned on harder substrates, built nests, and guarded their nests after spawning.

Sediment can kill eggs through abrasion and physical damage to the chorion; such damage often allows fungal spores to become established[69] and limits gaseous exchange by coating or blanketing the eggs. The latter case has been demonstrated repeatedly for salmonids, both in the laboratory and the field. These

*LC_{50} is the lethal concentration which results in 50 percent mortality for a designated exposure period (usually 24 to 96 hours).

fish require gravel of a certain diameter for spawning.[70] Deposition of fine sediment can clog intergravel interstices; this reduces spawning habitat and reduces the flow of intergravel water and thus the flow of oxygen to the eggs.[71] Sublethal oxygen deprivation may change the length of incubation, reduce size of hatching, and cause developmental abnormalities.[72]

Sediment deposition also increases egg mortality in lentic fishes which lay their eggs on surfaces.[73] Cases of centrarchids shunning or being unable to spawn in turbid areas have been reported.[74]

Hofbauer[75] reported that sediment impeded migration of European barbels but aided European eel migration. Gammon[76] and Reed[77] cited cases of fish emigrating from an area in response to heavy point source sedimentation. Heimstra, et al.,[78] found that turbidity destroyed normal social hierarchies in green sunfish and increased movement of juvenile and adult largemouth bass. Sediment may sweep eggs and larval fish out of their nursery habitat.[79] Larimore[80] noted that smallmouth bass fry experienced a loss of visual orientation under turbid conditions. This also influenced the periodicity and magnitude of larval drift. Geen et al.[81] found that the number of drifting catastomid larvae increased when sediment input increased.

Sediment which blankets or scours stream benthos reduces the availability of these organisms as fish food and thus often reduces fish densities.[82] In lentic systems, turbidity-related reductions in primary production and zooplankton can reduce planktivorous fish.[83]

Sediment can also reduce food availability by making prey less visible to their predators.[84] Vinyard and O'Brien[85] and Gardner[86] reported that turbidity reduces the ability of bluegill to detect zooplankton prey. As a result, fish may consume fewer plankton in a given time than under clear conditions. Bachmann[87] found that slight turbidity increases were detrimental to trout in that they induced them to stop feeding. On the other hand, decreased visibility may be beneficial to some species in that larval fish may escape predation[88] and nonselective feeders can gain a competitive edge.[89]

Food limitations will slow growth, cause developmental abnormalities, and ultimately cause starvation.[90] Hubbs and Whitlock[91] found that as a result of excessive siltation in the Arkansas River, the alimentary canals of young gizzard shad were jammed with inorganic material which contained only a limited amount of plankton. These fish had enlarged heads and underdeveloped tail regions. Buck[92] observed that bass and sunfish grew faster in clear ponds than in turbid ponds. Bulkley[93] reported that high suspended sediment concentrations in a river reduced available food to the extent that fish did not mature and were physically incapable of reproducing.

Suspended sediment may be responsible for reduced disease resistance in some fish.[94] Herbert and Merkins[95] reported increased incidents of finrot in rainbow trout as sediment concentrations increased Cairns[96] noted increased expoparasitism and sloughing off of mucus from fish epithelia exposed to sediment. Some fish kills have been attributed to exposure to sediment which has adsorbed toxic chemicals.[97]

3 POTENTIAL RATIONAL THRESHOLD VALUES

RTVs and Sediment

RTVs having potential application for Army impact analysis should have the following characteristics: (1) can be used by people with little or no practical knowledge of aquatic systems; (2) can be used to measure significant impacts on the higher, more visible trophic levels; (3) are applicable in studies of point source pollution; (4) represent a "yes" or "no" condition (threshold) pertaining to the significance of impact and are quantitative; (5) require minimum data input; and (6) can (and should) be used with output from analytical models. Riggins and Smith[98] outlined numerous potential RTVs for aquatic ecosystems and concluded that two types meet the above criteria: water quality standards and population levels.

Two characteristics of sediment pollution make it difficult for RTVs to measure its impact. First, sediment is not an isolated effect. It can alter light and temperature regimes in aquatic systems, causing changes in oxygen and other chemical characteristics. The organic component of sediment and sediment-transported nutrients and other materials can also alter the chemical regime. Furthermore, colonization of suspended sediment by microorganisms may change the water's chemical characteristics. All of these factors, in addition to the direct effects of sediment, can impact freshwater organisms. Even when analyzing point source situations, detailed chemical analysis of the sediment discharge is necessary, and the researcher must have a thorough knowledge of the physical, chemical, and biological state of the pre-impacted watershed and waterbody.

The second characteristic of sediment pollution is that sediment effects on freshwater organisms, especially in the higher trophic levels, are generally not acute, but occur over long periods of time. For example, sediment is usually not directly toxic to adult fish but impacts populations by altering reproductive fitness (egg and larval survival and condition, adult fecundity and behavior) both directly and through cumulative changes in the food web. Offspring from several successive years could be affected before the impacts would be noticed in the adult population. Therefore, standard bioassays which use adult fish as a basis are not an appropriate information base for potential sediment RTVs. Rather, extensive testing must be carried out to determine the effects of sediment on eggs, larval and juvenile stages, and adults, keeping in mind not only the amount of sediment but also the chemical and physical characteristics.

Sediment affects the entire food web. Generally, the lower trophic levels will be affected before the fish community. Thus, species in the lower trophic levels are the ideal indicator organisms. However, these lower organisms are very hard to identify at the species level, and their life histories are largely unknown. This makes it very hard to quantify the effects of sediment on them. Therefore, fish should probably be used as indicator organisms in lotic* systems. In determining which fish species to use, the researcher should examine the entire community of a particular system and pick several species which have the least tolerance to sediment.

Water Quality Standards

Although local water quality standards should never be exceeded, rigid international and national standards are not desirable, since natural variation in sediment loads and chemical makeup is so great.[99] Furthermore, many standards are rather arbitrarily set and do not incorporate any ecological information.[100] Water quality standards for suspended solids based on the response of the aquatic community, as taken from the literature, have been proposed by the European Inland Fisheries Advisory Commission[101] and adopted by the Committee on Water Quality Criteria in the United States. These are:

	Maximum Concentration Suspended Solids
High level of protection	25 mg/L
Moderate protection	80 mg/L
Low level of protection	400 mg/L
Very low level of protection	>400 mg/L

These standards probably are not supportable for wide-range use, since they are based mainly on information about European coldwater fishes. In addition, the "standard" concentrations are purely volumetric, and do not account for the chemical composition of the solids. Local volumetric water quality standards for sediment could be used for RTVs if they are based on the response of the local aquatic community and are accompanied by a detailed array of other chemical and physical standards, also based on community response. It will be a long time before the desired broad information base is available.

Relative Algal Growth Index: Potential RTV for Lentic Systems

Sediment affects phytoplankton by changing the light and nutrient regimes; these changes affect productivity and species composition. The effects are well-documented in lentic systems. The Relative Algal Growth Index (RAGI) simulates algal growth potential as a function of pre- and post-pollution conditions. The predictive information supplied by RAGI can be used to assess factors that limit growth and to evaluate shifts in the dominance of different algal groups.[103] This model already incorporates many nutrient parameters and can probably be modified for sediment use by adding a light-level component. Research should be conducted to determine if this is true and to test the model.

Fish Population Levels: Potential RTV for Lotic Systems

Sediment affects aquatic systems at the community level; it is therefore an oversimplification to represent single populations of organisms independent of their competitors, predators, and prey. Despite these limitations, population-level simulations can provide information for impact assessment by serving as indicators of stress for critical species (i.e., indicator species chosen on the basis of low sediment tolerance). Population levels can be simulated for almost any organism if survival and fecundity values are known and if the life history has been thoroughly documented. Such information is not available for many aquatic

*Inhabiting rivers and streams.

invertebrates, so the following discussion is limited to fish population levels as a potential RTV.

The most commonly used population simulation is the Leslie matrix.[104] This model describes the density-independent behavior of a single-species population with age-specific fecundity and survival rates and overlapping generations. The number in each age category (x) at a particular time (t) is represented by a column vector. To find the population density (N) at the next time ($t + 1$), the column vector is multiplied by a matrix of age-specific fecundity and survival values.

N_x = number of females alive in age group x to $x + 1$ at time t.

f_x = age-specific fecundity: the number of daughters born in the interval t to $t + 1$ per female alive aged x to $x + 1$, who will be alive in the age group $0 - 1$ at time $t + 1$.

s_x = age-specific survival: the probability that a female of age x (hence, in age group $x - 1$ to x) at time t will be alive with age $x + 1$ at time $t + 1$.

$$A = n \times n \text{ square matrix} = \begin{bmatrix} f_1 & \cdots & f_{n-1} & f_n \\ s_1 & \cdots & 0 & 0 \\ 0 & \cdots & s_{n-1} & 0 \end{bmatrix}$$

N_t and N_{t+1} = column vectors of dimension n which represent the age-specific population structure for t and $t + 1$ time periods.

$$N_{t+1} = A \cdot N_t \text{ or } N_t = A^t N_0$$

Leslie-derived population models have already been proposed and, in some cases, used to assess the effect of power plant operation on fish.[105] These models are all density-independent. One of the main effects of sediment on fish is its impact on the benthic or planktonic populations, which alters fish food availability. When food is limiting, the behavior of a fish population (whether it grows, is stable, or decreases) may depend on the size of the benthic or planktonic populations. Therefore, a density-independent model would not provide a realistic estimate. Density-dependent matrix models have been designed for terrestrial insect, bird, and mammal populations[106] and could probably be modified for use with fish populations. A density-dependent modification of the Leslie matrix proposed by Riggins and Smith[107] is discussed on p 11.

The existing fisheries models are deterministic, which means that given certain initial conditions, they predict one exact outcome.[108] Stochastic models incorporate the effects of chance events on populations and are therefore more biologically realistic. Horst[109] presented a stochastic fish model, but it is density-independent. Density-dependent stochastic versions of the Leslie model have been derived by Niven[110] and Pollard;[111] Sonleitner[112] presented a version which can interface with populations genetics models. Research should be conducted to determine if these models can be modified for impact analysis use.

Most of the fish population models discussed above are set up to evaluate mortality imposed through impingement, entrainment, and heat shock. Jensen[113] described the use of toxicity indices in age-specific population models. Such indices can be used as a database for population models to evaluate point-source sediment pollution in streams. However, the users of a model must always realize that the physical and chemical characteristics of sediment will differ in every area examined; thus, toxicity will have to be tested every time the model is to be used. This testing must be done on all life stages, from egg to reproductively mature adult, and will be a rigorous and time-consuming project.

Once toxicity data are obtained, each f_x and s_x term of the Leslie matrix model can be modified by coefficients representing both the project activities' impacts and their consequences.

$$f'_x = DDF_x \cdot DIF_x \cdot f_x \qquad \text{[Eq 1]}$$

and

$$s'_x = DDS_x \cdot DIS_x \cdot s_x \qquad \text{[Eq 2]}$$

where DDF_x = density-dependent control coefficient of fecundity of age class x

DIF_x = density-independent control coefficient of fecundity of age class x

DDS_x = density-dependent control coefficient of survivorship of age class x

DIS_x = density-dependent control coefficient of survivorship of age class x

$f_x \cdot s_x$ = natural fecundity and survivorship rates of population in a specified environmental setting.

Then f_x' and s_x' are used as the elements in the projection matrix. The DDS_x and DDF_x terms are functions of population density. DIS_x and DIF_x are functions of sediment impact variables in this case, the age-specific toxicity indices. Toxicity data will not reflect sediment-induced changes in habitat and food-base structure, which may impact the fish population as much, if not more, than direct effects on survival and fecundity. This greatly lowers the model's predictive power. Riggins and Smith[114] have developed a preliminary software package using this model, which incorporates basic physico-chemical environmental setting data into the impact parameters. Research should be done to determine if foodweb information can also be used.

Riggins and Smith[115] presented an example of how quantitative definitions of environmental impacts can be developed from population model output. In Figure 1, pre- and post-impacted population levels ($N_\emptyset(t)$ and $N_p(t)$) have been simulated using the modified matrix model discussed above. Impact magnitude $I(t)$ is measured by comparing the two simulated population levels and is given by the area under the $N_\emptyset(t)$ curve occurring within an appropriate time interval. Population-level impacts are then standardized by calculating the relative impact $RI(t)$, which is the ratio of the shaded area to the corresponding total area. Threshold values can then be placed on $RI(t)$ to designate "significant" impacts, and can be used as RTVs if all of the above-mentioned quantitative ecological information is available.

Riggins and Smith[116] then used the estimated relative impact to estimate population stability (S). Stability is defined as the reciprocal of the impact ($RI(t)$) on the basis of the reasoning that, for a given perturbation, the larger the impact, the smaller the population's stability.

$$S = 1 \Big/ \int_{t=0}^{\infty} (RI(t))^2 \, dt \qquad \text{[Eq 3]}$$

While the relative impact (the denominator of S) ranges from zero (no impact) to one (irreversible loss of species) a reasonable and convenient behavior its reciprocal, S, will range from one to infinity. Thus, S will provide values which would prove awkward to handle, especially when comparing impacts in different areas.

Community Diversity and Stability

Output from the relative algal growth and fish population models will provide information on the general directions and relative magnitudes of impacts rather than actual deterministic predictions of future standing crops. Furthermore, sediment impacts the entire aquatic community, so many effects may be overlooked. Therefore, some type of community analysis should be used as a check to the models discussed above.

One way of doing this is by using diversity indices. Although the predictive power of such indices is low, they could provide valuable information if combined with population simulations. Many different indices are used for pollution assessment, but few are reliable in all situations.[117] Pielou[118] and Peet[119] reviewed many of the indices and provided suggestions for using them in different environmental settings and analyzing different ecological problems.

Riggins and Smith[120] suggested that if the relative impact is simulated for multiple populations at various trophic levels, community stability can be estimated as

$$S_c = 1 \Big/ \frac{1}{M} \sum_{i=1}^{M} W_p(t) \int_{t=0}^{\infty} W_t(t) [RI_i(t)]^2 \, dt \qquad \text{[Eq 4]}$$

where M = number of populations simulated

$W_p(t)$ = weighting function for population

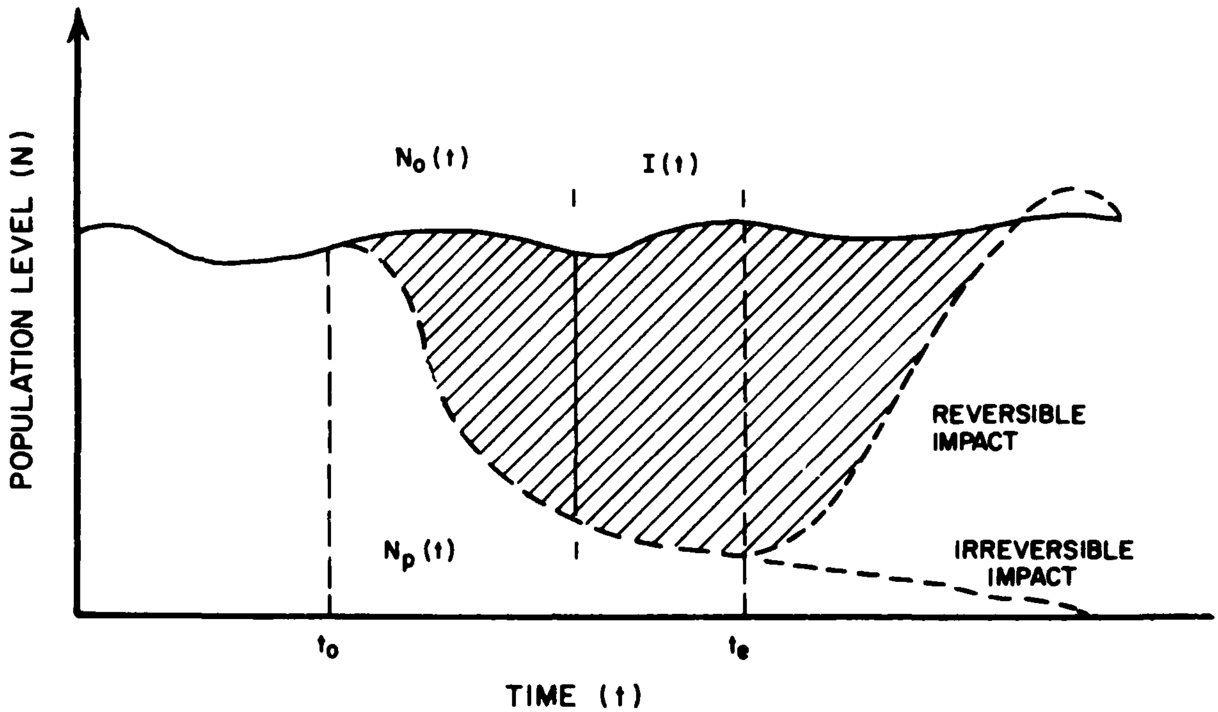
RI_i = relative impact on the population

$W_t(t)$ = weighting function for time period

S_c = community stability

dt = change in time

Here community stability is simply the reciprocal of the mean "total relative impact" averaged over all the species considered, with weighting functions incorporated to allow for quantitative imponderables, such as the role of the species in the ecological web or the rate at which the impact develops. As with population stability (S), S_c will range from one to infinity and would therefore be awkward to use. The "total relative impact" (reciprocal of S_c) is a good theoretical construct. In reality, it would be almost impossible to estimate, because the effects of sediment on the lower trophic levels (e.g., benthic macroinvertebrates) are difficult to quantify, especially with regard to different life stages. There is not yet a sufficient database to conduct sediment-related population simulations using these organisms.



t_o = time at which project activities are initiated

t_e = time at which all project activities have ended

$N_o(t)$ = baseline population simulated with environmental setting and no project activity specifications

$N_p(t)$ = impacted population simulated with environmental setting plus project activity specifications

$I(t)$ = impact at time $t = N_p(t) - N_o(t)$

Figure 1. Pre- and post-impacted population levels based on simulations. (From R. E. Riggins and E. D. Smith, *Aquatic Rational Threshold Value (RTV) Concepts for Army Environmental Impact Assessment*, Technical Report N-74/ADA073032 [U.S. Army Construction Engineering Research Laboratory, 1979.])

Reiger and Henderson[121] presented a model which uses diversity and stability measurements to analyze fish community structure and function. This model is based on the theories of MacArthur[122] and Margalef.[123] The information base required by this model is more rigorous than that required for single-species population simulations or typical diversity indices. Furthermore, the model does not examine the lower trophic levels, and these are the chief concern as a backup to fish simulations. Research at this time would best be directed toward finding ways of incorporating diversity information into RTV procedures. Once this information is obtained, ways of using stability measurements can be examined.

4 CONCLUSIONS

This study investigated the feasibility of using RTVs to predict sediment-related impacts in Army training areas. The research produced the following conclusions:

Local water quality standards may be used as RTVs if they are based on the response of the aquatic community to both physico-chemical and volumetric characteristics of sediment pollution in a specific area.

The RAGI and fish population levels appear to be feasible RTVs to predict sediment-related impact; however, even if used properly, they will not be exact predictors because they examine only a small portion of the community. Therefore, they should only be used with more traditional pollution assessment measurements, such as diversity indices. Further research will incorporate diversity information into the RTV procedures.

The RAGI may prove to be a viable RTV model for lentic systems if the model is modified to include a light-level component.

Fish population levels may be used as RTVs in lotic systems to assess sediment-induced stress on critical species if: (1) the population model used is density-dependent; (2) the model's database includes extensive information on the effects of both the physical and chemical characteristics of the local sediment input on all the life stages of the species in question; and (3) the model incorporates detailed physical, chemical, and biological data on the environmental setting of the species.

REFERENCES

The text reference numbers below refer to the superscript reference numbers in text. The source numbers refer to the entries in the Bibliography, which provide the full citations.

Text Reference Number	*Source(s)*
1	215
2	4, 91, 180, 238
3	64, 75
4	124
5	272
6	33, 53, 97
7	272
8	33, 115, 163
9	42
10	25
11	70
12	7, 8, 16, 33, 70, 189, 270
13	8, 33
14	32, 272
15	8, 180
16	73
17	20
18	238
19	33
20	90
21	12, 13, 18, 95
22	180
23	238
24	90
25	272
26	67
27	189
28	270, 271
29	281
30	132
31	244
32	95
33	3, 94, 136, 191, 274
34	12, 16, 189, 190
35	66, 67
36	125
37	90
38	189
39	180
40	239, 240
41	29, 50, 189, 244, 272, 281
42	238
43	281

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44	48, 165, 170, 195, 207, 252
45	84, 122, 125
46	37, 168
47	15, 16, 29, 56, 77, 79, 107, 109, 116, 123, 136, 162, 208, 254
48	191
49	66
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51	122, 123, 133, 174,
52	12, 18, 29, 51, 186
53	12, 18, 47, 69, 70, 217
54	14, 49, 150, 157, 208, 218
55	33, 70, 44, 148, 213
56	6
57	59
58	101
59	257
60	57, 153, 176
61	1, 2, 56, 57, 65, 77, 82, 139, 233, 235, 255, 256, 257
62	180
63	2, 10, 93, 105, 106, 144, 177, 216, 230, 249, 264
64	264
65	2, 28, 52, 75, 104, 105, 117, 167
66	10, 75, 243
67	229
68	180
69	51, 179, 180, 265
70	17, 131, 169, 200
71	2, 36, 85, 86, 111, 160, 164, 198, 199, 224, 225, 226, 227, 232, 275
72	60, 280
73	10, 43, 103, 177, 179, 265, 283
74	23, 172, 246, 250, 257
75	113
76	83, 84
77	208
78	104
79	51
80	140
81	88
82	51, 81, 107, 109, 217, 219, 242
83	188, 280
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85	262
86	87
87	11
88	61, 212, 248
89	200
90	251
91	120
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93	28
94	74, 180, 238
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96	33
97	20, 73
98	211
99	33
100	238
101	74
102	54
103	211
104	145, 146
105	45, 46, 98, 108, 118, 137, 149
106	72, 78, 141, 142, 185, 196, 197, 253, 258, 259
107	211
108	138
109	118, 119,
110	184, 185
111	206
112	237
113	130
114	211
115	211
116	211
117	34, 35, 41, 55, 134, 160, 166, 187, 192, 223, 276, 277, 278
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118	201, 202
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120	211
121	209
122	152
123	155, 156

BIBLIOGRAPHY

References preceded by an asterisk refer to topics other than the effects of sediment on freshwater organisms, but which have been cited in the text of the report. The remaining citations deal specifically with sediment effects and include an appropriate annotation.

1 AITKEN, W.W. 1936. THE RELATION OF SOIL EROSION TO STREAM IMPROVEMENT AND FISH LIFE. J. FOR. 34:1059-1061.--OBSERVATIONS ON FISH FAUNAL CHANGES IN IOWA BELIEVED TO HAVE BEEN CAUSED BY INCREASED SILTATION. SILT DEPOSITION. SUSPENDED SEDIMENT. TURBIDITY. FISH.

2 ALABASTER, J.S. 1972. SUSPENDED SOLIDS AND FISHERIES. PROC. R. SOC. LOND., BULL. 180:395-406.--LITERATURE REVIEW OF THE EFFECTS OF BOTH ORGANIC AND INORGANIC SUSPENDED SOLIDS ON FISH. SUSPENDED SEDIMENT. TURBIDITY. SILT DEPOSITION. SALMONIDAE. CYPRINIDAE. CENTRARCHIDAE.

3 ALLEN. K.R. 1960. EFFECT OF LAND DEVELOPMENT ON STREAM BOTTOM FAUNAS. PROC. NEW ZEALAND ECOL. SOC. 7:20-21.--LIST CHANGES IN THE ALGAL AND BENTHIC FAUNA RESULTING FROM INCREASED SILTATION FROM CONSTRUCTION AND FARMING. QUALITATIVE INFORMATION ONLY. SILT DEPOSITION. SUSPENDED SEDIMENT.TURBIDITY. PHYTOPLANKTON. ZOOPLANKTON.

4 *AMERICAN PUBLIC HEALTH ASSOCIATION (APHA). 1975. STANDARD METHODS FOR THE EXAMINATION OF WATER AND WASTEWATER. 14TH ED. AMERICAN PUBLIC HEALTH ASSOCIATION, WASHINGTON, D.C.

5 ANDERSON, H.W., AND G.A. JAMES. 1957. WATERSHED MANAGEMENT AND RESEARCH ON SALMON STREAMS OF SOUTHEASTERN ALASKA. J. FOR. 55:14-17.--PRESENTS QUALITATIVE INFORMATION ON EFFECTS OF SILTATION ON SALMONIDS. LOGGING RELATED ROAD CONSTRUCTION RESULTED IN 75% OF THE STREAM EROSION, SEDIMENT AND TURBIDITY, WHICH WAS DETRIMENTAL TO FISH. SUSPENDED SEDIMENT. TURBIDITY. SALMONIDAE.

6 ANDERSON, K.B., R.E. SPARKS, AND A.A. PAPARO. 1978. RAPID ASSESSMENT OF WATER QUALITY USING THE FINGERNAIL CLAM, MUSCULIUM TRANSVERSUM. USDA FIN. REP., PROJ. NO. B-097-ILL.--DISCUSSES PARTICLE SIZE AND CONCENTRATION (MG/L) OF SUSPENDED SILICA AND CLAY WHICH REDUCE THE PARTICLE TRANSPORT RATE OF THE GILLS. SUSPENDED SEDIMENT. TURBIDITY. SPHAERIIDAE.

7 ANGINO, E.E, AND W.J. O'BRIEN. 1968. EFFECT OF SUSPENDED MATERIAL ON WATER QUALITY. INT. ASSOC. SCI. HYDROL. 78:120-128.--EXCESS TURBIDITY MAY CAUSE CRITICAL REDUCTIONS IN OXYGEN PRODUCTION IN SOME STREAMS. SUSPENDED SEDIMENT. TURBIDITY. PHYTOPLANKTON.

8 APMANN, R.P., AND M.B. OTIS. 1965. SEDIMENTATION AND STREAM IMPROVEMENT. NEW YORK FISH GAME J. 12:117-126.--DISCUSSES EFFECTS OF CONSTRUCTION ACTIVITIES ON STREAM CHANNEL GEOMETRY AND FAUNA. NO QUANTITATIVE INFORMATION ON FAUNAL EFFECTS. SILT DEPOSITION. SUSPENDED SEDIMENT. TURBIDITY. FISH. BENTHIC MACROINVERTEBRATES.

9 ARMOUR, C.L. 1977. EFFECTS OF DETERIORATED RANGE STREAMS ON TROUT. U.S. BUR. LD. MGT., IDAHO ST. OFF., BOISE, IDAHO. 7PP.--A NONPRODUCING TROUT STREAM IN NEBRASKA RECEIVED HEAVY SILT LOADS DUE TO WATERSHED GRAZING. AN AREA OF THE WATERSHED WAS FENCED TO EXCLUDE LIVESTOCK AND WITHIN THREE YEARS THE STREAM WAS A MAJOR PRODUCER OF TROUT. SILT DEPOSITION. SUSPENDED SEDIMENT. SALMONIDAE.

10 AULD, A.H., AND J.R. SCHUBEL. 1978. EFFECTS OF SUSPENDED SEDIMENT OF FISH EGGS AND LARVAE: A LABORATORY ASSESSMENT. ESTUARINE COASTAL MAR. SCI. 6:153-164.--SUSPENDED SEDIMENT CONCENTRATIONS OF UP TO 1000 MG LDID NOT SIGNIFICANTLY AFFECT THE HATCHING SUCCESS OF YELLOW PERCH, BLUEBACK HERRING, ALEWIFE OR AMERICAN SHAD, BUT SIGNIFICANTLY LOWERED THE HATCHING SUCCESS OF WHITE PERCH AND STRIPED BASS. CONCENTRATIONS GREATER THAN 500 MG L-1 REDUCED THE SURVIVAL OF STRIPED BASS AND YELLOW PERCH LARVAE EXPOSED FOR 48-96 HOURS, AND CONCENTRATIONS GREATER THAN 100 MG L-1 REDUCED THE SURVIVAL OF SHAD LARVAE. SUSPENDED SEDIMENT. TURBIDITY. PERCIDAE. CLUPIDAE. PERCICHTHYIDAE.

11 BACHMANN, R.W. 1958. THE ECOLOGY OF FOUR NORTH IDAHO TROUT STREAMS WITH REFERENCE TO TO THE INFLUENCE OF FOREST ROAD CONSTRUCTION. M.S. THESIS. UNIV. IDAHO.--SLIGHT TURBIDITY INCREASES CAUSED CUTTHROAT TROUT (SALMO CLARKI) TO SEEK COVER AND STOP FEEDING. SUSPENDED SEDIMENT. TURBIDITY. SALMONIIDAE.

12 BALL, R.C., AND T.G. BAHR. 1975. INTENSIVE SURVEY: RED CEDAR RIVER, MICHIGAN. PP. 431-460 IN B.A. WHITTON, ED. RIVER ECOLOGY. UNIV. CALF. PRESS, BERKELEY.--IN THE RED CEDAR RIVER A LARGE INFLUX OF SEDIMENT DECREASED LIGHT, REDUCED AUTOTROPHIC PHOTOSYNTHESIS, SCOURED ORGANISMS FROM THE STREAM BED, SUFFOCATED MANY ORGANISMS, FILLED POOLS AND MODIFIED THE CHANNEL. SPECIES DIVERSITY OF BENTHIC MACROINVERTEBRATES WAS REDUCED. SILT DEPOSITION. SUSPENDED SEDIMENT. TURBIDITY. PHYTOPLANKTON. PERIPHYTON. BENTHIC MACROINVERTEBRATES.

13 BANARJEE, R.K., S.C. BANARJEE, AND B.B. PAKRASI. 1973. SILTATION IN DELTAIC REGIONS, ITS ROLE IN THE NUTRIENT AVAILABILITY IN PONDS. J. INLAND FISH. SOC. INDIA 5:208-214.--HEAVY SILTATION HINDERS AVAILABILITY OF PHOSPHORUS AND NITROGEN FROM THE SOIL AND THE NUTRIENT LEVEL IN THE WATER IS DIMINISHED LIMITING PHYTOPLANKTON GROWTH AND EVENTUALLY FISH PRODUCTION. SEDIMENT DATA AS DEPTH ON BOTTOM (CM). SILT DEPOSITION. SUSPENDED SEDIMENT. TURBIDITY. FISH.

14 BARTON, B.A. 1977. SHORT-TERM EFFECTS OF HIGHWAY CONSTRUCTION ON THE LIMNOLOGY OF A SMALL STREAM IN SOUTHERN ONTARIO. FRESHW. BIOL. 7:99-108.--STANDING CROP (KG/HA) OF FISH WAS REDUCED BELOW THE CONSTRUCTION SITE DUE TO SILT DEPOSITION. NO CHANGE IN NUMBERS OF RIFFLE MACROINVERTEBRATES WAS OBSERVED, BUT THERE WAS A NOTICEABLE CHANGE IN SPECIES COMPOSITION. SILT DEPOSITION. SUSPENDED SEDIMENT. TURBIDITY. SALMONIDAE. BENTHIC MACROINVERTEBRATES.

15 BARTON, D.R., AND R.R. WALLACE. 1979. EFFECTS OF ERODING OIL SAND AND PERIODIC FLOODING ON BENTHIC MACROINVERTEBRATE COMMUNITIES IN A BROWN-WATER STREAM IN NORTHEASTERN ALBERTA, CANADA. CAN. J. ZOOL. 57:533-541.--THE VARIETY AND RELATIVE ABUNDANCE OF PLECOPTERA AND TRICHOPTERA WERE CONSISTENTLY LOWER IN AREAS OF OIL SAND EXPOSURE DUE TO PHYSICAL ALTERATION OF THE SUBSTRATE AND SUSPENDED SAND. SILT DEPOSITION. SUSPENDED SEDIMENT. BENTHIC MACROINVERTEBRATES. PLECOPTERA. TRICHOPTERA.

16 BARTSCH, A.F. 1960. SETTABLE SOLIDS, TURBIDITY AND LIGHT PENETRATION AS FACTORS AFFECTING WATER QUALITY. PP. 118-127 IN BIOLOGICAL PROBLEMS IN WATER POLLUTION. U.S. PUB. HEALTH SERV., CINCINNATI, OHIO.--STUDY OF THE EFFECTS OF WASTES FROM A GLASS MANUFACTURING PLANT ON THE ALGAE, MACROPHYTES, AND BENTHOS OF THE POTOMAC RIVER. SUSPENDED SEDIMENT LIMITED ALGAL AND MACROPHYTE PRODUCTION BY REDUCING LIGHT AND INDIRECTLY BY ABRASION, COATING AND SMOTHERING. BENTHIC POPULATIONS WERE DEPLETED IN THE SETTLING ZONE WHERE TURBIDITY EXCEEDED 5000 PPM. SILT DEPOSITION. SUSPENDED SEDIMENT. TURBIDITY. PHYTOPLANKTON. PERIPHYTON. MACROPHYTES. BENTHIC MACROINVERTEBRATES.

17 BAYLESS, J.D. 1967. STRIPED BASS HATCHING AND HYBRIDIZATION EXPERIMENTS. PROC. ANN. CONF. SOUTHEASTERN ASSOC. GAME FISH COMM. 21:233-244.--TESTED HATCHING SUCCESS OF STRIPED BASS EGGS ON VARIOUS SUBSTRATES. CONCLUDED THAT EGGS NEED NOT BE SUSPENDED FOR SUCCESSFUL HATCH, BUT THAT IF ON SUBSTRATE SUFFOCATION FROM SILT INCREASES MORTALITY. SEDIMENT DATA AS PARTICLE SIZE DISTRIBUTION ON STREAM BOTTOM. SILT DEPOSITION. SUSPENDED SEDIMENT. PERCICHTHYIDAE.

18 BEAUMONT, P. 1975. HYDROLOGY. PP. 1-38 IN B.A. WHITTON, ED. RIVER ECOLOGY. UNIV. CALF. PRESS, BERKELEY.--BENTHIC ORGANISMS ARE SMOTHERED AND DAMAGED BY SEDIMENT CAUSING MORTALITY AND DEPOPULATION. SILT DEPOSITION. SUSPENDED SEDIMENT. BENTHIC MACROINVERTEBRATES.

19 BECK, W.M., JR. 1977. ENVIRONMENTAL REQUIREMENTS AND POLLUTION TOLERANCE OF COMMON FRESHWATER. CHIRONOMIDAE. EPA-600/4-77-024, ENVIRN. MONIT. SUPP. LAB., CINCINNATI, OHIO.--LISTS TURBIDITY TOLERANCE AND SOURCE REFERENCE FOR 220 TAXA OF CHIRONOMIDAE. SUSPENDED SEDIMENT. TURBIDITY. BENTHIC MACROINVERTEBRATES. CHIRONOMIDAE.

20 BENOIT, R.J.. J. CAIRNS, JR., AND C.W. REIMER. 1968. A LIMNOLOGICAL RECONNAISSANCE OF AN IMPOUNDMENT RECEIVING HEAVY METALS WITH EMPHASIS ON DIATOMS AND FISH. PP. 69-99 IN RESERVOIR FISHERIES RESEARCH SYMPOSIUM, AM. FISH. SOC., APR. 5-7, 1967.--ADSORPTION OF CHEMICALS ONTO SUSPENDED SEDIMENT LED TO A BUILD-UP OF TOXIC SUBSTANCES AND SUBSEQUENT FISH KILLS. SUSPENDED SEDIMENT. SALMONIDAE.

21 BENSON, N.G., AND B.C. COWELL. 1967. THE ENVIRONMENT AND PLANKTON DENSITY IN MISSOURI RIVER RESERVOIRS. PP. 358-373 IN RESERVOIR FISHERY RESOURCES SYMPOSIUM. SOUTHERN DIV. RESERVOIR COMM., AM. FISH. SOC., WASH., D.C.--IN THE MISSOURI RIVER IMPOUNDMENTS TURBIDITY ATTRIBUTED TO SUSPENDED SAND, SILT, AND CLAY PARTICLES WAS REGARDED AS THE STRONGEST LIMITING FACTOR TO PLANKTON ABUNDANCE. SUSPENDED SEDIMENT. TURBIDITY. PHYTOPLANKTON.

22 BRANSON, B.A., AND D.L. BATCH. 1972. EFFECTS OF STRIPMINING ON SMALL STREAM FISHES IN EAST-CENTRAL KENTUCKY. PROC. BIOL. SOC. WASH. 84:507-518.--FISHES WERE PROGRESSIVELY ELIMINATED FROM HEADWATERS DOWNSTREAM OR WERE FORCED TO EMIGRATE DOWNGRADE IN LOW-LEVEL ACID-MINE WATER EFFLUENCE CONTAINING HIGH LEVELS OF TURBIDITY AND SILTATION FROM SPOIL BANKS. SURFACE-FEEDING CREEK CHUB WERE ABLE TO REMAIN OVER ENSILTED BOTTOMS LONG AFTER OTHER SPECIES HAD BEEN ELIMINATED. SILT DEPOSITION. SUSPENDED SEDIMENT. TURBIDITY. CYPRINIDAE.

23 BREDER, C.M., JR., AND D.E. ROSEN. 1966. MODES OF REPRODUCTION IN FISHES. NAT. HIST. PRESS. GARDEN CITY, N.Y.--CENTRARCHID SUNFISHES WERE UNABLE TO EXCAVATE NESTS OR SPAWN IN AN INTENSELY SILTED POND. SILT DEPOSITION. SUSPENDED SEDIMENT. TURBIDITY. CENTRARCHIDAE.

24 BRENNAN, A., A.J. MCLACHLAN, AND R.S. WOTTON. 1978. PARTICULATE MATERIAL AND MIDGE LARVAE (CHIRONOMIDAE, DIPTERA) IN AN UPLAND RIVER. HYDROBIOLOGIA 59:67-74.--THE DENSITY OF STONE-SURFACE DWELLING MIDGES WAS REGULATED IN PART BY THE AMOUNT OF SUSPENDED AND DEPOSITED SEDIMENT AVAILABLE FOR TUBE-BUILDING. DESCRIBES PARTICLE SIZE AND CONCENTRATION. SILT DEPOSITION. SUSPENDED SEDIMENT. TURBIDITY. BENTHIC MACROINVERTEBRATES. CHIRONOMIDAE.

25 *BROWN, R. J. 1975. RESERVOIR AND LAKE SEDIMENTATION (A BIBLIOGRAPHY WITH ABSTRACTS). NTIS/PS-75/886/2ST NATL. TECH. INFOR. SERV., SPRINGFIELD, VIRGINIA.

26 BRUNGS, W.A., AND G.M. BAILEY. 1967. INFLUENCE OF SUSPENDED SOLIDS ON THE ACUTE TOXICITY OF ENDRIN TO FATHEAD MINNOWS. PROC. 21ST PURDUE IND. WASTE CONF. PT. I, 5:4-12.--LAB EXPERIMENTS INDICATED THAT ONLY A SMALL PORTION OF ENDRIN ASSOCIATED WITH BOTTOM SEDIMENTS BECOMES AVAILABLE TO FISH IN A SHORT TIME. THE POTENTIAL TOXICITY OF ENDRIN IN SOLUTION IS DECREASED ONLY BY THE PRESENCE OF A HIGHLY ADSORPTIVE MATERIAL SUCH AS ACTIVATED CARBON. SUSPENDED SEDIMENT. TURBIDITY. CYPRINIDAE.

27 BUCK, D.H. 1956. EFFECTS OF TURBIDITY ON FISH AND FISHING. TRANS. NORTH AM. WILDL. CONF. 21:249-261.--FIELD DETERMINATIONS OF THE EFFECTS OF EROSION SILT ON FISH GROWTH AND REPRODUCTION WAS CONDUCTED IN 39 FARM PONDS AND TWO RESERVOIRS. INCREASED TURBIDITY WAS ASSOCIATED WITH LOWER RECRUITMENT AND SLOWER GROWTH IN MOST SPECIES. FLATHEAD CATFISH PREFERRED THE MORE TURBID WATERS. TURBIDITY DATA IN PPM. FISH DATA AS LENGTH AND BIOMASS/ACRE. TURBIDITY. SILT DEPOSITION. CYPRINIDAE. ICTALURIDAE. CENTRARCHIDAE. ZOOPLANKTON.

28 BULKLEY, R.V. 1975. CHEMICAL AND PHYSICAL EFFECTS ON THE CENTRARCHID BASSES. PP. 286-294 IN R.H. STROUD AND H. CLEPPER, EDS. BLACK BASS BIOLOGY AND MANAGEMENT. SPORT FISHING INSTIT., WASH., D.C.--HIGH SUSPENDED SOLIDS REDUCED AVAILABLE FOOD FOR LARGEMOUTH BASS TO THE POINT WHERE GROWTH WAS SLOWED AND REPRODUCTIVE MATURITY NEVER ATTAINED. THE SOLIDS ALSO EFFECTED THE RESPIRATORY SYSTEM CAUSING COUGHING. SUSPENDED SOLIDS. SUSPENDED SEDIMENT. TURBIDITY. CENTRARCHIDAE.

29 BURRIS, J.W., AND C.M. COOPER. 1977. THE INFLUENCE OF TURBIDITY ON PLANKTONIC AND BENTHIC ORGANISMS. PROC. MISS. WATER RESOURC. CONF. PP. 87-91. WATER RESOURC. RES. INST., JACKSON, MISS.--EFFECTS OF SUSPENDED AND DEPOSITED SEDIMENT ON PHYTOPLANKTON AND BENTHOS OF THE GRENADA RESERVOIR AND TRIBUTARIES. AREAS OF LARGE CONCENTRATIONS OF SUSPENDED SEDIMENT IN FLOWING WATERS OR IN DELTA REGIONS GENERALLY HAD LOW SPECIES DIVERSITY. SILT DEPOSITION. SUSPENDED SEDIMENT. TURBIDITY. PHYTOPLANKTON. BENTHIC MACROINVERTEBRATES.

30 BUSHNELL, J.H. 1974. BRYOZOANS (ECTOPROCTA). PP. 157-193 IN C.W. HART AND S.L.H. FULLER, EDS. POLLUTION ECOLOGY OF FRESHWATER INVERTEBRATES. ACADEMIC PRESS, N.Y.--DISCUSSION OF THE EFFECTS OF TURBIDITY AND RELATED LIGHT PENETRATION ON ECTOPROCT GROWTH AND ABUNDANCE. SILT DEPOSITION. SUSPENDED SEDIMENT. TURBIDITY. ECTOPROCTA.

31 BUTLER, G.E. 1936. ARTIFICIAL PROPAGATION OF WALLEYED PIKE. TRANS. AM. FISH. SOC. 66:277-278.--A SERIOUS LOSS OF WALLEYE EGGS OCCURRED IN THE GULL HARBOR, MANITOBA HATCHERY WHEN WIND INCREASED THE AMOUNT OF SUSPENDED SEDIMENT IN THE INTAKE WATER. SUSPENDED SEDIMENT. TURBIDITY. ESOCIDAE.

32 BUTLER, J.L. 1964. INTERACTION OF EFFECTS BY ENVIRONMENTAL FACTORS ON PRIMARY PRODUCTIVITY IN PONDS AND MICROECOSYSTEMS. PH.D. THESIS, OKLA. STATE UNIV., STILLWATER.--A SERIOUS LOSS OF WALLEYE EGGS OCCURRED IN THE GULL HARBOR, MANITOBA HATCHERY WHEN WIND INCREASED THE AMOUNT OF SUSPENDED SEDIMENT IN THE INTAKE WATER. SUSPENDED SEDIMENT.TURBIDITY. PERCIDAE.

33 CAIRNS, J., JR. 1967. SUSPENDED SOLIDS STANDARDS FOR THE PROTECTION OF AQUATIC ORGANISMS. PURDUE UNIV. ENG. BULL. 129:16-27.--COMPREHENSIVE LITERATURE REVIEW. ECOLOGICAL EFFECTS OF SUSPENDED SOLIDS ARE DISCUSSED INCLUDING MECHANICAL ACTION, BLANKETING ACTION OF SEDIMENT, REDUCTION OF LIGHT PENETRATION, SURFACE FOR GROWTH OF BACTERIA, ADSORPTION OF CHEMICALS AND REDUCTION OF TEMPERATURE FLUCUATIONS. EFFECTS OF TURBIDITY ON FISH POPULATIONS, SPAWNING AND EGG HATCHING RATES. SUSPENDED SEDIMENT. TURBIDITY.

34 *CAIRNS, J., JR. 1968. THE SEQUENTIAL COMPARISON INDEX: A SIMPLIFIED METHOD FOR NONBIOLOGISTS TO ESTIMATE RELATIVE DIFFERENCES IN BIOLOGICAL DIVERSITY IN STREAM POLLUTION STUDIES. J. WATER POLLUT. CONTR. FED. 40:1607-1613.

35 *CAIRNS, J., JR., AND K. L. DICKSON. 1971. A SIMPLE METHOD FOR THE BIOLOGICAL ASSESSMENT OF THE EFFECTS OF WASTE DISCHARGES ON AQUATIC BOTTOM DWELLING ORGANISMS. J. WATER POLLUT. CONTR. FED. 40:755-782.

36 CAMPBELL, H.J. 1954. THE EFFECT OF SILTATION FROM GOLD DREDGING ON THE SURVIVAL OF RAINBOW TROUT AND EYED EGGS IN POWDER RIVER, OREGON. OREG. ST. GAME COMM. 3PP.--SEDIMENT CAN DIRECTLY DECREASE THE SURVIVAL OF TROUT EGGS BY DIMINISHING THE FLOW OF INTERSTITIAL WATER WITHIN THE REDDS, THEREBY LIMITING THE AMOUNT OF AVAILABLE OXYGEN. SILT DEPOSITION. SUSPENDED SEDIMENT. TURBIDITY. SALMONIDAE.

37 CARLANDER, K.D., C.A. CARLSON, V. GOOCH, AND T.L. WENKE. 1967. POPULATIONS OF HEXAGENIS MAYFLY NAIADS IN POOL 19, MISSISSIPPI RIVER, 1959-1963. ECOLOGY 48:873-878.--SILT BOTTOM AREAS ARE NEEDED BY BURROWING MAYFLY NYMPHS BECAUSE THEY CONSTURCT U-SHAPED RESPIRATION TUBES IN THE MUDDY BOTTOMS. SILT DEPOSITION. SUSPENDED SEDIMENT. BENTHIC MACROINVERTEBRATES. EPHEMEROPTERA.

38 CHANDLER, D.C. 1940. LIMNOLOGICAL STUDIES OF WESTERN LAKE ERIE. I. PLANKTON AND CERTAIN PHYSICAL-CHEMICAL DATA OF THE BASS ISLANDS REGION, FROM SEPT., 1938 TO NOV., 1939. OHIO J. SCI. 40:291-336.--TURBIDITY WAS GREATEST AT TIMES OF LOW PLANKTON PRODUCTIVITY AND LOWEST AT TIMES OF HIGH PLANKTON PRODUCTIVITY. TURBIDITY DATA IN PPM. SUSPENDED SEDIMENT. TURBIDITY. PHYTOPLANKTON.

39 CHANDLER, D.C. 1942. LIMNOLOGICAL STUDIES OF WESTERN LAKE ERIE. III. PHYTOPLANKTON AND PHYSICAL-CHEMICAL DATA FROM NOV., 1939 - NOV., 1940. OHIO J. SCI. 42:24-44.--WHEN THE AVERAGE TURBIDITY WAS 25 PPM OR GREATER IMMEDIATELY PRECEEDING OR DURING A PHYTOPLANKTON PULSE, THE PULSE WAS OF SHORT DURATION. DIATOMS COMPOSED A GREATER PERCENTAGE OF THE TOTAL PHYTOPLANKTON POPULATION WHEN THE TURBIDITY EXCEEDED 25 PPM. GREEN ALGAE AND BLUEGREEN ALGAE WERE MORE COMMON AT TURBIDITIES OF 20 PPM OR LESS. SUSPENDED SEDIMENT. TURBIDITY. PHYTOPLANKTON.

40 CHANDLER, D.C., AND O.B. WEEKS. 1945. LIMNOLOGICAL STUDIES OF WESTERN LAKE ERIE. V. RELATION OF LIMNOLOGICAL AND METEOROLOGICAL CONDITONS TO THE PRODUCTION OF PHYTOPLANKTON IN 1942. ECOL. MONOGR. 15:435-456.--DURING THE SPRING OF 1942 THE SIZE OF THE PHYTOPLANKTON CROP WAS CONTROLLED BY TURBIDITY. TURBIDITY DATA IN PPM. SUSPENDED SEDIMENT. TURBIDITY. PHYTOPLANKTON.

41 *CHANDLER, J.R. 1970. A BIOLOGICAL APPROACH TO WATER QUALITY MANAGEMENT. WATER POLLUT. CONTR. 4:415-422.

42 CHANDLER, O.C. 1944. LIMNOLOGICAL STUDIES OF WESTERN LAKE ERIE. IV. RELATION OF LIMNOLOGICAL AND CLIMATIC FACTORS TO THE PHYTOPLANKTON OF 1941. TRANS. AM. MICROSC. SOC. 63:203-236.--ANNUAL VARIATIONS IN THE ABUNDANCE OF PHYTOPLANKTON IN WESTERN LAKE ERIE ARE RELATED TO VARIATIONS IN TURBIDITY AND TEMPERATURE. TURBIDITY DATA IN PPM. SUSPENDED SEDIMENT. TURBIDITY. PHYTOPLANKTON.

43 CHEW, R.L. 1969. INVESTIGATION OF EARLY LIFE HISTORY OF LARGEMOUTH BASS IN FLORIDA. FL. GAME FRESHW. FISH COMM. PROJ. REPT. F-024-R-02.--LARGEMOUTH BASS SPAWNING WAS VERY LIMITED IN TURBID LAKE HOLLINGSWORTH, FLORIDA. MOST FEMALES FAILED TO SHED THEIR EGGS AND LATER GRADUALLY REABSORBED THEM. SUSPENDED SEDIMENT. TURBIDITY. CENTRARCHIDAE.

44 CHIBA, K., AND Y. OHSHIMA. 1957. EFFECTS OF SUSPENDED PARTICLES ON THE PUMPING AND FEEDING OF MARINE BIVALVES, ESPECIALLY OF JAPANESE LITTLE-NECK CLAMS. BULL. JAP. SOC. SCI. FISH. 23:348-354.--THERE WAS A TENDENCY FOR THE MARINE BIVALVES TO COMPENSATE FOR INCREASED TURBIDITY BY EXCRETING PSEUDO-FECES AND MAINTAINING PUMPING RATES. SEDIMENT DATA IN MG/L. SUSPENDED SEDIMENT. TURBIDITY. PELECYPODA.

45 *CHRISTENSEN, S.W., D.L. DEANGELIS, AND A.G. CLARK. 1977. DEVELOPMENT OF A STOCK-PROGENY MODEL FOR ASSESSING POWER PLANT EFFECTS ON FISH POPULATIONS. PP. 196-227 IN W. VAN WINKLE (ED.), ASSESSING THE EFFECTS OF POWER PLANT-INDUCED MORTALITY ON FISH POPULATIONS. PERGAMON PRESS, NEW YORK.

46 *CHRISTENSEN, S.W., W. VAN WINKLE, AND J.S. MATTRICE. 1975. DEFINING AND DETERMINING THE SIGNIFICANCE OF IMPACTS: CONCEPTS AND METHODS. PUBL. NO. 747, ENVIRON. SCI. DIV., OAK RIDGE NATL. LAB., OAK RIDGE NATL. LAB., OAK RIDGE, TENNESSEE.

47 CHUTTER, F.M. 1968. THE EFFECTS OF SILT AND SAND ON THE INVERTEBRATE FAUNA OF STREAMS AND RIVERS. HYDROBIOLOGIA 34:57-76.--LITERATURE REVIEW OF THE EFFECTS OF SILT AND SAND ON STREAM BENTHOS. SILT DEPOSITION. SUSPENDED SEDIMENT. TURBIDITY. BENTHIC MACROINVERTEBRATES.

48 CHUTTER, F.M. 1970. HYDROBIOLOGICAL STUDIES IN THE CATCHMENT OF THE VAAL DAM, SOUTH AFRICA, PART I. RIVER ZONATION AND THE BENTHIC FAUNA. INT. REV. GES. HYDROBIOL. 55:445-494.--THE DISTRIBUTION OF THE INVERTEBRATE FAUNA WAS CORRELATED WITH THE AMOUNT OF SILT AND SAND IN THE RIVERBEDS. SOME SPECIES HAD LIMITED DISTRIBUTIONS BECAUSE THEY WERE UNABLE TO LIVE IN SILTY HABITATS. SILT DEPOSITION. SUSPENDED SEDIMENT. BENTHIC MACROINVERTEBRATES.

49 CIBOROWSKI, J.J.H., D.J. POINTING, AND L.D. CORKUM. 1977. THE EFFECTS OF CURRENT VELOCITY AND SEDIMENT ON THE DRIFT OF THE MAYFLY EPHEMERELLA SUBVARIA MCDUNNOUGH. FRESHW. BIOL. 7:567-572.--SUSPENDED SEDIMENT LEVELS IN THE LIGHT DID NOT INFLUENCE THE NUMBER OF NYMPHS IN THE DRIFT. DURING DARKNESS DRIFT DENSITY WAS SIGNIFICANTLY GREATER UNDER HIGH SEDIMENT CONDITIONS. EXPERIMENTS WERE CONDUCTED IN AN ARTIFICIAL STREAM. SUSPENDED SEDIMENT. TURBIDITY. BENTHIC MACROINVERTEBRATES. EPHEMEROPTERA.

50 CLAFFEY, F.J. 1955. THE PRODUCTIVITY OF OKLAHOMA WATERS WITH SPECIAL REFERENCE TO RELATIONSHIPS BETWEEN TURBIDITIES FROM SOIL, LIGHT PENETRATION, AND THE POPULATIONS OF PLANKTON. M.S. THESIS. OKLA. STATE UNIV., STILLWATER.--VOLUME OF NET PLANKTON IN FARM PONDS DECREASED WITH INCREASED TURBIDITY. GIVES % LIGHT PENETRATION FOR THE DIFFERENT TURBIDITIES (IN PPM). TURBIDITY. ZOOPLANKTON.

51 CLEARY, R.E. 1958. OBSERVATIONS ON FACTORS AFFECTING SMALLMOUTH BASS PRODUCTION IN IOWA. J. WILDL. MGT. 20:353-359.--SMALLMOUTH BASS NESTED, SPAWNED AND HATCHED DURING SPORADIC PERIODS OF HIGH TURBIDITY IN STREAMS IN IOWA, BUT STREAMS WHICH REMAINED TURBID FOR LONG PERIODS OF TIME SELDOM PRODUCED EITHER SMALLMOUTH BASS FINGERLINGS OR GOOD SMALLMOUTH BASS FISHING. SEDIMENT DATA IN PPM. SILT DEPOSITION. TURBIDITY. CENTRARCHIDAE.

52 COLE, A.E. 1935. WATER POLLUTION STUDIES IN WISCONSIN. EFFECTS OF INDUSTRIAL (PULP AND PAPER MILL) WASTES ON FISH. SEWAGE WKS. J. 7:280-302.--DEMONSTRATED EXPERIMENTALLY THAT FISH MAY MOVE THROUGH VERY MUDDY WATER AND RECEIVE LITTLE OR NO MECHANICAL INJURY TO THE GILLS AS LONG AS THE MUCUS BARRIER REMAINS UNIMPAIRED. SUSPENDED SEDIMENT. TURBIDITY. FISH.

53 *COMMITTEE ON SEDIMENTATION (COS). 1976. PROCEEDINGS OF THE THIRD FEDERAL INTER-AGENCY SEDIMENTATION CONFERENCE. PB-245 100, WATER RESOURCES COUNCIL, WASHINGTON, D.C.

54 COMMITTEE ON WATER QUALITY CRITERIA (CWQC). 1973. WATER QUALITY CRITERIA 1972. A REPORT OF THE COMMITTEE ON WATER QUALITY CRITERIA. WATER QUALITY CRITERIA 1972. A REPORT OF THE COMMITTEE ON WATER QUALITY CRITERIA. ENVIRONMENTAL STUDIES BOARD, NAT. ACAD. SCI., NAT. PROT. AG., EPA-R3-73-003. GOV. PRINTING OFFICE, WASH., D.C.--LIST RECOMMENDED MAXIMUM CONCENTRATIONS OF SUSPENDED SOLIDS (MG/L) FOR DIFFERENT PROTECTION LEVELS FOR FRESHWATER FISH. SUSPENDED SOLIDS, SUSPENDED SEDIMENT. TURBIDITY. FISH. SALMONIDAE.

55 *COOK, S.E.K. 1976. QUEST FOR AN INDEX OF COMMUNITY STRUCTURE SENSITIVE TO WATER POLLUTION. ENVIRON. POLLUT. 11:269-288.

56 CORDONE, A.J., AND D.W. KELLEY. 1961. THE INFLUENCES OF INORGANIC SEDIMENT ON THE AQUATIC LIFE OF STREAMS. CALF. FISH GAME 47:189-228.--REVIEW OF LITERATURE ON THE IMPACTS OF SEDIMENTS ON BOTTOM FAUNA AND SALMONIDS OF COLD WATER STREAMS IN NORHT AMERICA. SILT DEPOSITION. SUSPENDED SEDIMENT. TURBIDITY. BENTHIC MACROINVERTEBRATES. SALMONIDAE.

57 CROSS, F.B. 1967. HANDBOOK OF FISHES OF KANSAS. MUS. NAT. HIST., UNIV. KANSAS MISC. PUBL. 45.--REPRODUCTION AND SURVIVAL OF CHANNEL CATFISH IN CLEAR PONDS IS LIMITED BECAUSE OF BASS PREDATION, WHEREAS EXCESSIVE SURVIVAL IN TURBID PONDS RESULTS IN STUNTED POPULATIONS. CHARACTERIZES HABITAT OF BLACK BULLHEAD AS PREFERRING HIGH TURBIDITY AND SOFT BOTTOMS. SILT DEPOSITION. SUSPENDED SEDIMENT. TURBIDITY. ICTALURIDAE.

58 DARNALL, R.M. 1976. IMPACTS OF CONSTRUCTION ACTIVITIES IN WETLANDS OF THE UNITED STATES. ECOL. RES. SER., EPA 600/3-76-045.--LITERATURE REVIEW OF EFFECTS OF DEPOSITED AND SUSPENDED SEDIMENT ON AQUATIC ORGANISMS, WITH SPECIAL ATTENTION TO WETLAND AREAS. SILT DEPOSITION. SUSPENDED SEDIMENT. TURBIDITY. BENTHIC MACROINVERTEBRATES. FISH.

59 DAVIS, H.C. 1960. EFFECTS OF TURBIDITY-PRODUCING MATERIALS IN SEA WATER ON EGGS AND LARVAE OF THE CLAM (MERCENARIA MERCENARIA). BIOL. BULL. 118:48-54.--SOME CLAM EGGS DEVELOPED NORMALLY IN CONCENTRATIONS OF 4.0 G/L CLAY, PRECIPITATED CHALK OR FINELY GROUND FULLER'S EARTH, BUT THE PERCENTAGE DEVELOPING NORMALLY DECREASED AS THE CONCENTRATION OF THESE SUSPENDED MATERIALS INCREASED. SUSPENDED SEDIMENT. TURBIDITY. VENERIDAE.

60 DAVIS, J.C. 1975. MINIMAL DISSOLVED OXYGEN REQUIREMENTS OF AQUATICE LIFE WITH EMPHASIS ON CANADIAN SPECIES: A REVIEW. J. FISH. RES. BOARD CAN. 32:2295-2332.--BLANKETING OF FISH EGGS WITH SEDIMENT RESULTS IN OXYGEN DEPRIVATION AND HYPOXIC STRESS. THIS CAN RESULT IN ALTERED LENGTH OF INCUBATION PERIOD, REDUCED SIZE AT HATCHING, AND DEVELOPMENTAL DEFORMITIES AS WELL AS MORTALITY. SILT DEPOSITION. SUSPENDED SEDIMENT. FISH.

61 DOAN, K.H. 1941. RELATION OF SAUGER CATCH TO TURBIDITY IN WESTERN LAKE ERIE. OHIO J. SCI. 41:449-452.--TURBIDITY WAS CORRELATED WITH INCREASED SAUGER CATCHES IN LAKE ERIE. HIGHER TURBIDITIES MAY ACT TO PREVENT STICKINESS IN SAUGER EGGS, GIVE YOUNG FRY PROTECTION FROM PREDATORS AND FACILITATE FEEDING BY CONCENTRATING PLANKTONIC ORGANISMS NEAR THE SURFACE. TURBIDITY DATA IN PPM: FISH DATA AS BIOMASS. TURBIDITY. PERCIDAE. ZOOPLANKTON.

62 DOAN, K.H. 1942. SOME METEORLOGICAL AND LIMNOLOGICAL CONDITIONS AS FACTORS IN THE ABUNDANCE OF CERTAIN FISHES IN LAKE ERIE. ECOL. MONOGR. 12:293-314.--INCREASED SPRING TURBIDITIES IN LAKE ERIE WERE ASSOCIATED WITH LOWER TOTAL OHIO CATCHES IN THE SAME YEAR, HAD NO DIRECT EFFECT ON THE PERCH FISHING, BUT WERE FOLLOWED BY INCREASED SAUGER CATCHES 3 YEARS LATER. ACTUAL TURBIDITY DATA NOT PRESENTED. FISH DATA AS BIOMASS. TURBIDITY. SALMONIDAE. PERCIDAE. ICTALURIDAE. CYPRINIDAE. ZOOPLANKTON.

63 DOUDOROFF, P. 1976. KEYNOTE ADDRESS - REFLECTIONS ON PICKLE-JAR ECOLOGY. PP. 3-19 IN J. CAIRNS, JR., K.L. DICKSON, AND G.F. WESTLAKE, EDS. BIOLOGICAL MONITORING OF WATER AND EFFLUENT QUALITY. AM. SOC. TEST. MATERIALS SPEC. TECH. PUBL. 607.--SUSPENDED SEDIMENT, THROUGH EFFECTS ON FOOD AVAILABILITY, FORAGING EFFICIENCY AND SUBSEQUENT REDUCED FISH GROWTH COULD INDIRECTLY AFFECT SEVERAL ASPECTS OF MATURATION AND FECUNDITY IN FISH. SUSPENDED SEDIMENT. TURBIDITY. FISH.

64 *DUCHROW, R.M., AND W.H. EVERHART. 1971. TURBIDITY MEASUREMENT. TRANS. AM. FISH. SOC. 100:682-690.

65 DURHAM, L., AND L.S. WHITLEY. 1971. BIOLOGICAL SURVEY OF STREAMS OF COLES COUNTY, ILLINOIS 1967-1970. EPA, WATER POLLUT. CONTROL RES. SER. 18050 DZZ 06/71.--COMPARES STREAM FISH FAUNA OF COLES CO. IN 1967-1970 WITH 1913, AND FOUND CHANGES WHICH WERE ATTRIBUTED TO LAND USE CHANGES AND GREATER SILTATION OCCURRING IN THE STREAMS. SILT DEPOSITION. SUSPENDED SEDIMENT. TURBIDITY. FISH.

66 ECKBLAD, J.W., N.L. PETERSON, K. OSTLIE, AND A. TEMTE. 1977. THE MORPHOMETRY, BENTHOS AND SEDIMENTATION RATES OF A FLOODPLAIN LAKE IN POOL 9 OF THE UPPER MISSISSIPPI RIVER. AM. MIDL. NAT. 97:433-443.--SEDIMENTATION IN THE LAKE HAS BEEN ACCOMPANIED BY ENCROACHMENT OF SAGITTARIA STANDS ON THE OPEN WATER PORTION OF THE LAKE AND A SUBSEQUANT CHANGE IN SPECIES DOMINANCE. SPHAERIUM AND HEXAGENIA ARE BEING REPLACED BY CHIRONOMIDAE. OLIGOCHAETA AND GASTROPODA. SILT DEPOSITION. SUSPENDED SEDIMENT. MACROPHYTES. BENTHIC MACROINVERTEBRATES.

67 EDWARDS, D. 1969. SOME EFFECTS OF SILTATION UPON AQUATIC MACROPHYTE VEGETATION IN RIVERS. HYDROBIOLOGIA 34:29-37.--THE MAJOR EFFECT OF SUSPENDED SEDIMENT ON MACROPHYTES IS THROUGH REDUCTION IN LIGHT INTENSITY AND SUBSEQUENT DECREASE IN PHOTOSYNTHESIS. DEPOSITION OF SILT ON LEAVES WILL FURTHER REDUCE PHOTOSYNTHESIS, AND SOME MACROPHYTES MAY BE BURIED AND ELIMINATED BY RAPID ACCUMULATION OF SILT. SILT DEPOSITION. SUSPENDED SEDIMENT. TURBIDITY. MACROPHYTES.

68 ELDER, D.E., AND W.M. LEWIS. 1955. AN INVESTIGATION AND COMPARISON OF THE FISH POPULATIONS OF TWO FARM PONDS. AM. MIDL. NAT. 53:390-395.--COMPARES DENSITY, BIOMASS, STANDARD LENGTH AND COEFFICIENT OF CONDITION (K) OF BLUEGILL AND WHITE CRAPPIE IN A CLEAR AND IN A TURBID FARM POND. FISH IN THE CLEAR POND GREW FASTER AND HAD A HIGHER K. TURBIDITY INFORMATION QUALITATIVE. SUSPENDED SEDIMENT. TURBIDITY. CENTRARCHIDAE.

69 ELLIS, M.M. 1931. SOME FACTORS AFFECTING THE REPLACEMENT OF THE COMMERCIAL FRESH-WATER MUSSELS. U.S. DEPT. COMMERCE, BUR. FISH., FISH. CIRC. 7.--EROSION SILT DESTROYED MUSSEL POPULATIONS IN THE MISSISSIPPI, TENNESSEE, AND OHIO RIVERS. SILT DEPOSITION. SUSPENDED SEDIMENT. UNIONIDAE.

70 ELLIS, M.M. 1936. EROSION SILT AS A FACTOR IN AQUATIC ENVIRONMENTS. ECOLOGY 17:29-42.--EXPERIMENTAL FIELD STUDY SHOWED THAT MOST COMMON FRESHWATER MUSSELS WERE UNABLE TO SURVIVE WHEN SILT ONE FOURTH OF AN INCH DEEP OR MORE WAS ALLOWED TO ACCUMULATE ON THE BOTTOM OF AN OTHERWISE SATISFACTORY HABITAT. DATA PRESENTED AS DEPTH OF SILT DEPOSITION. CONTAINS LITERATURE REVIEW OF EARLY WORK ON PHYSICAL AND CHEMICAL CHANGES IN LAKES AND STREAMS AS A RESULT OF SUSPENDED OR DEPOSITED SEDIMENT. TURBIDITY. SUSPENDED SEDIMENT. SILT DEPOSITION. UNIONIDAE.

71 ELLIS, M.M. 1937. DETECTION AND MEASUREMENT OF STREAM POLLUTION. BULL. U.S. BUR. FISH. 22:365-437.--MADE 514 DETERMINATIONS OF TURBIDITY AT 202 LOCATIONS ON MAJOR RIVERS THROUGHOUT THE U.S. AND NOTED A DECREASE IN FISH SPECIES RICHNESS WITH INCREASED TURBIDITY. SUSPENDED SEDIMENT. TURBIDITY.

72 *ENGSTOM-HEG. 1970. PREDATION, COMPETITION AND ENVIRONMENTAL VARIABLES: SOME MATHAMATICAL MODELS. J. THEORET. BIOL. 27:175-195.

73 ERICHSEN, L.V., AND K. KAEMMERER. 1950. THE EFFECT OF MINE WASTE WATERS CONTAINING METAL SALTS ON THE BIOLOGICAL CONDITIONS IN A RIVER SYSTEM. GAS-U. WASSERFACH. 91:16-19.--FISH IN A GERMAN RIVER WERE BEING KILLED BY THE DEPOSITION OF IRON HYDROXIDE PARTICLES ON THEIR SKIN AND GILLS. PEATY MUD WAS ADDED, AND THE PARTICLES ADSORBED THE IRON HYDROXIDE AND THE FISH POPULATION INCREASED. SUSPENDED SEDIMENT. TURBIDITY. FISH.

74 EUROPEAN INLAND FISHERIES ADVISORY COMMISSION (EIFAC). 1965. WATER QUALITY CRITERIA FOR EUROPEAN FRESHWATER FISH. REPORT ON FINELY DIVIDED SOLIDS AND INLAND FISHERIES. INT. J. AIR WATER POLLUT. 9:151-168.--REVIEWS EFFECTS OF SUSPENDED SOLIDS AND SEDIMENT ON SALMONIDS AND OTHER FISH IN EUROPE AND GIVES EUROPEAN PROTECTIVE STANDARDS. SILT DEPOSITION. SUSPENDED SEDIMENT. TURBIDITY. FISH.

75 EVERHART, W.H., AND R.M. DUCHROW. 1970. EFFECTS OF SUSPENDED SEDIMENT ON AQUATIC ENVIRONMENTS. U.S. BUR. RECLAM. PROJ. COMPL. REP. NO. 14-06-D-659. COLO. ST. UNIV., FORT COLLINS, CO. --LITERATURE REVIEW OF PHYSICAL, CHEMICAL AND BIOLOGICAL EFFECTS OF ORGANIC AND INORGANIC SUSPENDED SOLIDS ON THE AQUATIC ENVIRONMENT AND FRESHWATER ORGANISMS. INCLUDES A REVIEW OF TURBIDITY MEASUREMENT METHODS. SILT DEPOSITION. SUSPENDED SEDIMENT. TURBIDITY. PHYTOPLANKTON. PERIPHYTON. ZOOPLANKTON. BENTHIC MACROINVERTEBRATES. FISH.

76 FORESTER, T.S., AND J.M. LAWRENCE. 1978. EFFECTS OF GRASS CARP AND CARP ON POPULATIONS OF BLUEGILL AND LARGEMOUTH BASS IN PONDS. TRANS. AM. FISH. SOC. 107:172-175.--A DECREASE IN STANDING CROP OF BLUEGILL IN PONDS WAS ATTRIBUTED TO INCREASED TURBIDITY CAUSED BY CARP ROILING THE SEDIMENTS. SUSPENDED SEDIMENT. TURBIDITY. CYPRINIDAE. CENTRARCHIDAE.

77 FORSHAGE, A., AND N.E. CARTER. 1973. EFFECTS OF GRAVEL DREDGING ON THE BRAZOS RIVER. PROC. 27TH ANN. CONF. SOUTHEAST ASSOC. GAME FISH COMM. P. 695.--HABITAT DESTRUCTION AND SILTATION CAUSED A SHIFT IN FISH POPULATIONS FROM LARGEMOUTH BASS, GREEN SUNFISH, BLUEGILL, AND REDEAR TO WHITE CRAPPIE, WARMOUTH, CHANNEL CATFISH, AND FLATHEAD CATFISH. SILT DEPOSITION. TURBIDITY. ICTALURIDAE. CENTRARCHIDAE.

78 *FRANK, P.W. 1960. PREDICTION OF POPULATION GROWTH FORM IN DAPHNIA PULEX CULTURES. AM. NAT. 94:357-372.

79 FREMLING, C.R. 1970. MAYFLY DISTRIBUTION AS A WATER QUALITY INDEX. EPA WATER POLLUT. CONTROL RES. SER. 16030 DQH 11/70.--DISCUSSES SEDIMENT LOAD TOLERANCES OF DIFFERENT TYPES OF BURROWING MAYFLIES. SILT DEPOSITION. SUSPENDED SEDIMENT. TURBIDITY. BENTHIC MACROINVERTEBRATES. EPHEMEROPTERA.

80 FULLER, S.L.H. 1974. CLAMS AND MUSSELS (MOLLUSCA: BIVALVIA). PP. 215-257 IN C.W. HART AND S.L.H. FULLER, EDS. POLLUTION ECOLOGY OF FRESHWATER INVERTEBRATES. ACADEMIC PRESS, N.Y.--LITERATURE REVIEW OF THE EFFECTS OF SUSPENDED AND DEPOSITED SEDIMENT ON FRESHWATER BIVALVES. SILT DEPOSITION. SUSPENDED SEDIMENT. TURBIDITY. MARGARITIFERIDAE. UNIONIDAE. SPHAERIIDAE.

81 FWPCA 1967. EFFECTS OF POLLUTION ON AQUATIC LIFE RESOURCES OF THE SOUTH PLATTE RIVER BASIN IN COLORADO. S. PLATTE RIVER BASIN PROJ. TECH. ADVISORY INVEST. BR. REP. PR-11.--A SECTION OF THE SOUTH PLATTE RIVER, COLORADO WHICH CARRIED 80 TO 110 PPM SUSPENDED SOLIDS FROM A GRAVEL WASHING OPERATION WAS FOUND TOCONTAIN ONLY 15% TO 40% AS MANY FISH AS A REGION ABOVE THE GRAVEL PIT. SUSPENDED SEDIMENT. TURBIDITY. FISH.

82 GALE, W.F., AND C.A. GALE. 1976. SELECTION OF ARTIFICIAL SPAWNING SITES BY THE SPOTFIN SHINER (NOTROPIS SPILOPTERUS). J. FISH. RES. BOARD CAN. 33:1906-1913.--SPOTFIN SHINER NESTING SITES WERE REDUCED BY SILTATION. SILT DEPOSITION. SUSPENDED SEDIMENT. TURBIDITY. CYPRINIDAE.

83 GAMMON, J.R. 1968. THE EFFECT OF INORGANIC SEDIMENT ON THE MACROINVERTEBRATE AND FISH POPULATIONS OF A CENTRAL INDIANNA STREAM. INDIANA ACAD. SCI. PROC. 78:203.--DESCRIBES EFFECTS OF SUSPENDED SEDIMENT FROM A CRUSHED LIMESTONE QUARRY ON DENSITY AND STANDING CROPS OF MACROINVERTEBRATES AND FISH. SEDIMENT DATA IN MG/L. SILT DEPOSITION. SUSPENDED SEDIMENT. TURBIDITY. BENTHIC MACROINVERTEBRATES. FISH.

84 GAMMON, J.R. 1970. THE EFFECT OF INORGANIC SEDIMENT ON STREAM BIOTA. WATER POLLUT. CONTROL RES. SER. 18050 DWC 12/70.--LITERATURE REVIEW OF THE EFFECTS OF SUSPENDED AND DEPOSITED SEDIMENT ON STREAM BENTHOS AND FISH. SILT DEPOSITION. SUSPENDED SEDIMENT. TURBIDITY. BENTHIC MACROINVERTEBRATES. FISH.

85 GANGMARK, H.A., AND R.D. BROAD. 1955. EXPERIMENTAL HATCHING OF KING SALMON IN MILL CREEK, A TRIBUTARY OF THE SACRAMENTO RIVER. CALF. FISH GAME 41:233-242.--SALMON EGG MORTALITY WAS ASSOCIATED WITH EROSION AND SILTING DURING STREAM FLOW CHANGES. SILT DEPOSITION. SUSPENDED SEDIMENT. SALMONIDAE.

86 GANGMARK, H.A., AND R.G. BAKKALA. 1960. A COMPARATIVE STUDY OF UNSTABLE AND STABLE (ARTIFICIAL CHANNEL) SPAWNING STREAMS FOR INCUBATING KING SALMON AT MILL CREEK. CALF. FISH GAME 46:151-164.--SPAWN LOSSES RESULTED FROM DEPOSITION OF SILT AND SAND IN SALMON REDDS. SEDIMENT DATA IN PPM. SILT DEPOSITION. SUSPENDED SEDIMENT. SALMONIDAE.

87 GARDNER, M.B. 1980. MECHANISMS OF SIZE SELECTIVITY BY PLANKTIVOROUS FISH: A TEST OF HYPOTHESES. UNPUB. MANUSCRIPT.--TURBIDITY REDUCES THE REACTIVE DISTANCE AND THE NUMBER OF ZOOPLANKTON THAT CAN BE SEEN SIMULTANEOUSLY BY A BLUEGILL, AND THEREFORE LOWERED THE MEAN NUMBER OF DAPHNIA EATEN BY BLUEGILL DURING AN EXPERIMENT. TURBIDITY DID NOT SIGNIFICANTLY EFFECT SIZE SELECTIVITY. SUSPENDED SEDIMENT. TURBIDITY. CENTRARCHIDAE. ZOOPLANKTON.

88 GEEN, G., T. NORTHCOTE, G. HARTMAN, AND C. LINDSEY. 1966. LIFE HISTORIES OF TWO SPECIES OF CATOSTOMID FISHES IN SIXTEEN MILE LAKE, BRITISH COLUMBIA, WITH PARTICULAR REFERENCE TO INLET STREAM SPAWNING. J. FISH. RES. BOARD CAN. 23:1761-1788.--INCREASES IN NUMBERS OF DRIFTING LARVAE WAS ASSOCIATED WITH HIGHER WATER AND TURBIDITY LEVELS IN A SMALL STREAM. SUSPENDED SEDIMENT. TURBIDITY. CATOSTOMIDAE.

89 GINETZ, R.M., AND P.A. LARKIN. 1976. FACTORS AFFECTING RAINBOW TROUT (SALMO GAIRDNERI) PREDATION ON MIGRANT FRY OF SOCKEYE SALMON (ONCORHYNCHUS NERKA). J. FISH. RES. BOARD CAN.--RAINBOW TROUT FIND IT MORE DIFFICULT TO OBTAIN FOOD IN TURBID WATERS. SUSPENDED SEDIMENT. TURBIDITY. SALMONIDAE.

90 GOLDMAN, C.R., AND B.L. KIMMEL. 1978. BIOLOGICAL PROCESSES ASSOCIATED WITH SUSPENDED SEDIMENT AND DETRITUS IN LAKES AND RESERVOIRS. PP. 19-44 IN J. CAIRNS, JR., E.F. BENFIELD, AND J.R. WEBSTER, EDS. CURRENT PERSPECTIVES ON RIVER-RESERVOIR ECOSYSTEMS. NORTH AM. BENTHOLOGICAL SOC., COLUMBIA, MO.--ASSOCIATION OF MICROORGANISMS WITH SUSPENDED PARTICLES CONSTITUTES A MAJOR ROUTE OF ENERGY FLOW IN LAKES AND RESERVOIRS. SUSPENDED SEDIMENT PARTICLES MAY BE VIEWED AS EXCHANGE SURFACES AT WHICH BOTH GAINS (ADSORPTION, COLONIZATION, ASSIMILATION) AND LOSSES (CELL LYSIS, EXCRETION, INGESTION, DECOMPOSITION, LEACHING) OF ENERGY AND NUTRIENTS OCCUR CONTINUOUSLY. SUSPENDED SEDIMENT.

91 *GOLTERMAN, H.L. 1975. CHEMISTRY. PP 29-80 IN B.A. WHITTON (ED.), RIVER ECOLOGY. UNIV. CALIFORNIA PRESS, BERKELEY.

92 *GOLTERMAN, H.L. 1977. INTERACTIONS BETWEEN SEDIMENTS AND FRESHWATER. PROC. INTERN. SYMP., ASTERDAM, SEPT. 6-10, 1976. DR. W. JUNK, THE HAGUE.

93 GRIFFIN, L.D. 1938. EXPERIMENTS ON TOLERANCE OF YOUNG TROUT AND SALMON FOR SUSPENDED SEDIMENT IN WATER. OREGON DEP. GEOL. MINERAL INDUST., BULL. 10:28-31.--SALMON AND TROUT FINGERLINGS IN HATCHERY TROUGHS LIVED FOR 3 TO 4 WEEKS IN SUSPENDED SILT CONCENTRATIONS OF 300 TO 750 PPM, AND COULD ENDURE SUSPENSIONS OF 6500 PPM FOR SHORT PERIOS OF TIME WITHOUT DAMAGE. SUSPENDED SEDIMENT. TURBIDITY. SALMONIDAE.

94 GRIFFITH, R.E. 1955. ANALYSIS OF PHYTOPLANKTON YIELDS IN RELATION TO CERTAIN PHSYICAL AND CHEMICAL FACTORS OF LAKE MICHIGAN. ECOLOGY 36:543-552.--HIGHER TURBIDITIES PRECEEDED A PHYTOPLANKTON PULSE AND DURING THE PULSE TURBIDITIES WERE LOW. CHRYSOPHYTA DENSITIES WERE HIGHER UNDER HIGH TURBIDITIES, MYXOPHYTA AND CHLOROPHYTA UNDER LOW TURBIDITIES. TURBIDITY ESTIMATED WITH A LAKE COLOR INDEX. SUSPENDED SEDIMENT. TURBIDITY. PHYTOPLANKTON.

95 GROBBELAAR, J.V. 1979. EARLY OBSERVATIONS ON SOME LIMNOLOGICAL CHARACTERISTICS OF THREE ORANGE FREE STATE IMPOUNDMENTS. J. LIMNOL. SOC. SOUTH AFRICA 51:47-49.--DISCUSSES SUSPENDED SILT IN SOUTH AFRICAN RESERVOIRS WITH RESPECT TO PRIMARY PRODUCTIVITY AND AS A SUBSTRATE FOR NUTRIENT ADSORPTION. SUSPENDED SEDIMENT. TURBIDITY. PHYTOPLANKTON.

96 GUNDERSON, D.R. 1968. FLOODPLAIN USE RELATED TO STREAM MORPHOLOGY AND FISH POPULATIONS. J. WILDL. MGT. 32:507-514.--TROUT IN SECTIONS OF STREAMS, OR STREAMS WHERE THE WATERSHED WAS NOT SUBJECTED TO GRAZING BY CATTLE, WERE 27-400 PERCENT MORE ABUNDANT THAN IN GRAZED SECTIONS. THIS IS RELATED TO SUSPENDED AND DEPOSITED SILT (PPM). SILT DEPOSITION. SUSPENDED SEDIMENT. TURBIDITY. SALMONIDAE.

97 *GUY, H.P., AND G.E. FERGUSON. 1970. STREAM SEDIMENT: AN ENVIRONMENTAL PROBLEM. J. SOIL WATER CONSRV. 25:217-221.

98 *HALL, C.A.S. 1974. MODELS AND THE DECISION MAKING PROCESS: THE HUDSON RIVER POWER PLANT CASE. PP. 203-218 IN S.A. LEVIN (ED.), ECOSYSTEM ANALYSIS AND PREDICTION. PROC. SIAMS-SIMS CONF., ALTA, UTAH.

99 HAMBRIC, R.N. 1958. SOME EFFECTS OF TURBIDITY ON BOTTOM FAUNA. M.S. THESIS, OKLA. AGRIC. MECH. COLL., STILLWATER.--DESCRIBES THE % VOLUME OF BENTHOS FROM 18 CLEAR AND TURBID PONDS IN OKLAHOMA. TURBIDITY IN JTU'S. SILT DEPOSITION. SUSPENDED SEDIMENT. TURBIDITY. BENTHIC MACROINVERTEBRATES.

100 HAMILTON, J.D. 1961. THE EFFECT OF SAND-PIT WASHINGS ON STREAM FAUNA. VERH. INT. VEREIN. LIMNOL. 14:435-439.--SAMPLED BENTHOS ABOVE AND BELOW SILTY DISCHARGE IN STREAM. QUALITATIVE ANALYSIS OF FISH ABUNDANCE AND SPAWNING. BENTHOS WAS UNALTERED UNLESS COMPLETELY COVERED BY DEPOSITED SILT. SUSPENDED SAND AND SILT HAD NO DIRECT EFFECT ON ADULT FISH BUT PROBABLY REDUCED EGG SURVIVAL. SEDIMENT DATA IN PPM, PARTICLE SIZES GIVEN. SILT DEPOSITION. SUSPENDED SEDIMENT. TURBIDITY. SALMONIDAE. BENTHIC MACROINVERTEBRATES.

101 HARRISON, A.D., AND T.D.W. FARINA. 1965. A NATURALLY TURBID WATER WITH DELETARIOUS EFFECTS ON THE EGG CAPSULES OF PLANORBID SNAILS. ANN. TROP. MED. PARASIT. 59:327-330.--SUSPENDED SEDIMENT ADVERSELY AFFECTED THE EGG-LAYING AND SUBSEQUENT DEVELOPMENT OF LYMNAEA NATALENSIS, BULINUS GLOBOSUS AND B. PFIEFFERI, ALTHOUGH EACH SPECIES HAD DIFFERENT TOLERANCE LEVELS. SEDIMENT DATA IN PPM. SUSPENDED SEDIMENT. TURBIDITY. GASTROPODA.

102 HARRISON, F.W. 1974. SPONGES (PORIFERA: SPONGILLIDAE). PP. 29-63 IN C.W. HART AND S.L.H. FULLER, EDS. POLLUTION ECOLOGY OF FRESHWATER INVERTEBRATES. ACADEMIC PRESS, N.Y.--LITERATURE REVIEW OF THE EFFECTS OF SILTATION ON FRESHWATER SPONGES. SILT DEPOSITION. SUSPENDED SEDIMENT. TURBIDITY. SPONGILLIDAE.

103 HASSLER, T.J. 1970. ENVIRONMENTAL INFLUENCES ON EARLY DEVELOPMENT AND YEAR-CLASS STRENGTH OF NORTHERN PIKE IN LAKES OAHE AND SHARPE, SOUTH DAKOTA. TRANS. AM. FISH. SOC. 99:369-375.--EGGS OF THE NORTHERN PIKE, ESOX LUCIUS, SUFFERED 97% OR HIGHER MORTALITY IN TWO MISSOURI RESERVOIRS WHEN SEDIMENT DEPOSITION EXCEED 1.0 MM PER DAY. MORTALITIES WERE LOWER IF EGGS WERE COVERED AFTER THE SIXTH DAY OF INCUBATION. SILT DEPOSITION. SUSPENDED SEDIMENT. TURBIDITY. ESOCIDAE.

104 HEIMSTRA, N.W., D.K. DAMKOT, AND N.G. BENSON. 1969. SOME EFFECTS OF SILT TURBIDITY ON BEHAVIOR OF JUVENILE LARGEMOUTH BASS AND GREEN SUNFISH. U.S. DEP. INTER., BUR. SPORTS FISH. WILDL. TECH. PAP. 20:9P.--BEHAVIOR OF JUVENILE LARGEMOUTH BASS AND GREEN SUNFISH IN AQUARIUMS WAS MEASURED UNDER CONDITIONS OF CLEAR WATER, 4-6 JTU, AND 14-16 JTU FOR 30 DAYS. THE ACTIVITY OF BASS WAS SIGNIFICANTLY REDUCED BY TURBIDITY, SUNFISH ACTIVITY WAS REDUCED, BUT NOT SIGNIFICANTLY. FEEDING AND ATTACK BEHAVIOR WAS NOT INFLUENCED. SCRAPING BEHAVIOR OF BOTH SPECIES WA S HIGHER UNDER TURBID CONDITIONS. THERE WAS EVIDENCE THAT TURBIDITY DISTURBED NORMAL SOCIAL HIERARCHIES IN GREEN SUNFISH. SUSPENDED SEDIMENT. TURBIDITY. CENTRARCHIDAE.

105 HERBERT, D.W.M., AND J.C. MERKENS. 1961. THE EFFECT OF SUSPENDED MINERAL SOLIDS ON THE SURVIVAL OF TROUT. AIR WATER POLLUT. 5:46-55.--RAINBOW TROUT WERE EXPOSED TO SUSPENSIONS OF KAOLIN AND DIATOMACEOUS EARTH. AT CONCENTRATIONS OF 30 PPM AND 90 PPM THERE WERE NO OBSERVABLE EFFECTS. 50% DIED IN TWO TO TWELVE WEEKS AT 270 PPM. CELL PROLIFERATION AND FUSION OF THE LAMELLAE IN THE GILLS OF THE EXPOSED FISH WAS OBSERVED. SUSPENDED SEDIMENT. SALMONIDAE.

106 HERBERT, D.W.M., AND J.M. RICHARDS. 1963. THE GROWTH AND SURVIVAL OF FISH IN SOME SUSPENSIONS OF SOLIDS OF INDUSTRIAL ORIGIN. INT. J. AIR WAT. POLLUT. 7:297-302.--A QUESTIONAIRE SURVEY IN ENGLAND, SCOTLAND, AND WALES INDICATED A CRITICAL SUSPENDED SOLIDS LOAD FOR RIVER FISHERIES OF 100 TO 300 PPM. SUSPENDED SOLIDS. SUSPENDED SEDIMENT. TURBIDITY. SALMONIDAE.

107 HERBERT, D.W.M., J.S. ALABASTER, M.C. DART, AND R. LLOYD. 1961. THE EFFECT OF CHINA-CLAY WASTES ON TROUT STREAMS. INT. J. AIR WAT. POLLUT. 5:56-74.--NORMAL BROWN TROUT POPULATIONS OCCURRED WHERE THE CONCENTRATION OF SUSPENDED SEDIMENT WAS 60 PPM, BUT IN STREAMS CARRYING 1000 TO 6000 PPM CHINA-CLAY WASTES ONLY ONE-SEVENTH THE NORMAL DENSITY WAS FOUND. THIS WAS PROBABLY DUE TO REDUCTION OF FOOD INVERTEBRATES AND SILTING OF SPAWNING SITES AND, PERHAPS, SOME GILL DAMAGE. SEDIMENT PARTICLE SIZES GIVEN. DENSITY, AGE, WEIGHT AND GILL CONDITION OF FISH GIVEN. SILT DEPOSITION. SUSPENDED SEDIMENT. TURBIDITY. SALMONIDAE.

108 *HERRICKS, E.E., AND M.J. SALE. 1976. AQUATIC ECOSYSTEM CONSIDERATIONS IN WATER-ENERGY DEVELOPMENT. ENGINEERING FOUNDATION CONFERNECE ON WATER FOR ENERGY DEVELOPMENT. WASHINGTON, D.C.

109 HILL, D.M. 1972. STREAM FAUNAL RECOVERY AFTER MANGANESE STRIP MINE RECLAMATION. NO. 72-16289. UNIV. MICROFILMS, ANN ARBOR, MICH.--TURBIDITY AND SILTATION IN STREAMS RECEIVING STRIP MINE RUNOFF CAUSED AN OVERALL REDUCTION IN THE NUMBER OF BOTTOM ORGANISMS WHICH RESULTED IN CHANGES IN DENSITY, DIVERSITY AND COMMUNITY STRUCTURE. TURBIDITY IN JTU. SILT DEPOSITION. SUSPENDED SEDIMENT. TURBIDITY. CYPRINIDAE. COTTIDAE. BENTHIC MACROINVERTEBRATES.

110 HILLIS, E.H., J.G. BOONE, C.R. LELOSE, AND G.J. MURPHY. 1964. A LITERATURE REVIEW OF THE EFFECTS OF TURBIDITY AND SILTATION ON AQUATIC LIFE. STAFF REP., DEPT. CHESAPEAKE BAY AFFAIRS, ANNAPOLIS, MD.--LITERATURE REVIEW OF THE EFFECTS OF TURBIDITY AND SUSPENDED AND DEPOSITED SEDIMENT ON FRESHWATER AND ESTUARINE BENTHOS AND FISH. SILT DEPOSITION. SUSPENDED SEDIMENT. TURBIDITY. BENTHIC MACROINVERTEBRATES. FISH.

111 HOBBS, D.F. 1937. NATURAL REPRODUCTION OF QUINNAT SALMON, BROWN AND RAINBOW TROUT IN CERTAIN NEW ZEALAND WATERS. NEW ZEALAND MARINE DEPT., FISH BULL. NO. 6.--FIELD SURVEY ON SALMONID EGG, FRY AND ADULT DENSITY, CONDITION AND MORTALITY. SEDIMENT CONCENTRATION CAN DIRECTLY DECREASE THE SURVIVAL OF TROUT AND SALMON EGGS BY LIMITNG INTERSTITIAL WATER AND THEREBY LIMITING OXYGEN. SEDIMENT DATA AS DEPTH AND PARTICLE SIZE. SILT DEPOSITION. SUSPENDED SEDIMENT. TURBIDITY. SALMONIDAE.

112 HOBBS, H.H., JR., AND E.T. HALL, JR. 1974. CRAYFISHES (DECAPODA: ASTACIDAE). PP. 195-212 IN C.W. HART AND S.L.H. FULLER, EDS. POLLUTION ECOLOGY OF FRESHWATER INVERTEBRATES. ACADEMIC PRESS, N.Y.--DISCUSSION AND LITERATURE REVIEW OF THE EFFECTS OF CHANNELIZATION AND SILTATION ON CRAYFISHES. SILT DEPOSITION. SUSPENDED SEDIMENT. TURBIDITY. BENTHIC MACROINVERTEBRATES. ASTACIDAE.

113 HOFBAUER, J. 1963. DER AUFSTEIG DER FISCHE IN DEN FISHPASSEN DES MEHRFACH GESTAUTEN MAINES. ARCH. FISCH WISS. 13:92-125.--DURING PERIODS OF INCREASING TURBIDITY BARBEL (BARBUS FLUVIATILIS) MIGRATION DECREASED AND EUROPEAN EEL (ANGUILLA ANGUILLA) MIGRATION INCREASED SUSPENDED SEDIMENT. TURBIDITY. ANGUILLIDAE. CYPRINIDAE.

114 HOLDEN, P.B. 1980. ECOLOGY OF RIVERINE FISHES IN REGULATED STREAM SYSTEMS WITH EMPHASIS ON THE COLORADO RIVER. PP. 57-74 IN J.V. WARD AND J.A. STANFORD, EDS. THE ECOLOGY OF REGULATED STREAMS. PLENUM PUBL. CO., N.Y., N.Y.--HABITAT VARIABILITY COUPLED WITH THE AMOUNT OF TURBIDITY AND FINE SEDIMENTS IS USUALLY REDUCED BELOW DAMS BECAUSE THE RESERVOIR ACTS AS A SILT TRAP. NATIVE COLORADO RIVER SYSTEM FISH ARE WELL ADAPTED TO EXTREMES AND NO POPULATION CHANGES ARE DOCUMENTED DUE TO CHANGES IN TURBIDITY. TURBIDITY. SILT DEPOSITION. CYPRINIDAE. CATOSTOMIDAE.

115 *HOLEMAN, J.N. 1968. THE SEDIMENT YIELD OF THE MAJOR RIVERS OF THE WORLD. WATER RESOURC. RES. 4:737-747.

116 HOOPES, D.T. 1960. UTILIZATION OF MAYFLIES AND CADDISFLIES BY SOME MISSISSIPPI RIVER FISHES. TRANS. AM. FISH. SOC. 84:32-34. --INCREASED SILTATION HAS BEEN ACCOMPANIED BY AN INCREASE IN THE MAYFLY HEXAGENIA LIMBATA AND A DECREASE IN H. BILINEATA IN AREAS OF THE MISSISSPPI RIVER. SILT DEPOSITION. SUSPENDED SEDIMENT. TURBIDITY. BENTHIC MACROINVEREBRATES. EPHEMEROPTERA.

117 HORKEL, J.D., AND W.D. PEARSON. 1976. EFFECTS OF TURBIDITY ON VENTILATION RATES AND OXYGEN CONSUMPTION OF GREEN SUNFISH. TRANS. AM. FISH. SOC. 105:107-113.--AT TURBIDITY LEVELS EXCEEDING 1012 FTU AT 15 C AND 898 FTU AT 25 C VENTILATION RATES INCREASED 50-70%. EVIDENCE SUGGESTS THAT INCREASED VENTILATION RATES UNDER HIGHLY TURBID CONDITIONS ARE A MEANS OF COMPENSATING FOR REDUCED RESPIRATORY EFFICIENCY AND A STRATEGY FOR MAINTAINING A CONSTANT OXYGEN UPTAKE. TURBIDITY. CENTRACHIDAE.

118 *HORST, T.J. 1977A. USE OF THE LESLIE MATRIX FOR ASSESSSING ENVIRONMENTAL IMPACT WITH AN EXAMPLE FOR A FISH POPULATION. TRANS. AM. FISH. SOC. 106:253-257.

119 *HORST, T.J. 1977B. EFFECTS OF POWER STATION MORTALITY ON FISH POPULATION STABILITY IN RELATIONSHIP TO LIFE HISTORY STRATEGY. IN W. VAN WINKLE (ED.), ASSESSING THE EFFECTS OF POWER PLANT-INDUCED MORTALITY ON FISH POPULATIONS. PERGAMON PRESS, NEW YORK.

120 HUBBS, C.L., AND S.C. WHITLOCK. 1929. DIVERSE TYPES OF YOUNG IN A SINGLE SPECIES OF FISH, THE GIZZARD SHAD. MICH. ACAD. SCI. ARTS LETTERS 10:461-482.--ALIMENTARY CANALS OF YOUNG GIZZARD SHAD WERE FOUND JAMMED WITH INORGANIC MATERIALS AND CONTAINED LIMITED PLANKTON AS A RESULT OF EXCESSIVE SILTATION IN THE ARKANSAS RIVER. THIS RESULTED IN THE SHAD HAVING ENLARGED HEADS AND UNDERDEVELOPED TAIL REGIONS. SUSPENDED SEDIMENT. TURBIDITY. ZOOPLANKTON. CLUPEIDAE.

121 HUDSON, P.L., AND B.C. COWELL 1967. DISTRIBUTION AND ABUNDANCE OF PHYTOPLANKTON AND ROTIFERS IN A MAIN STEM MISSOURI RIVER RESERVOIR. PROC. SOUTH DAK. ACAD. SCI. 1966:84-106.--AN INVERSE RELATIONSHIP EXISTED BETWEEN NET PHYTOPLANKTON ABUNDANCE AND TURBIDITY IN SECTIONS OF LEWIS AND CLARK LAKE. SUSPENDED SEDIMENT. TURBIDITY. PHYTOPLANKTON.

122 HYNES, H.B.N. 1960. THE BIOLOGY OF POLLUTED WATERS. LIVERPOOL UNIV. PRESS, LIVERPOOL, UNITED KINGDOM.--GENERAL DISCUSSION OF DIRECT AND INDIRECT EFFECTS OF SUSPENDED INERT SOLIDS ON LOTIC ORGANISMS. SILT DEPOSITION. SUSPENDED SEDIMENT. TURBIDITY. PHYTOPLANKTON. PERIPHYTON. MACROPHYTES. BENTHIC MACROINVERTEBRATES.

123 HYNES, H.B.N. 1963. IMPORTED ORGANIC MATTER AND SECONDARY PRODUCTIVITY IN STREAMS. INT. CONGR. ZOOL. 16:324-329.--NORMAL STREAM FAUNA WERE REPLACED BY HIGH NUMBERS OF CHIRONOMIDAE AND TUBIFICIDAE DUE TO SUSPENDED SEDIMENT FROM A COLLIERY. SILT DEPOSITION. SUSPENDED SEDIMENT. TURBIDITY. BENTHIC MACROINVERTEBRATES. CHIRONOMIDAE. TUBIFICIDAE.

124 HYNES, H.B.N. 1970A. THE ECOLOGY OF RUNNING WATERS. UNIV. TORONTO PRESS, TORONTO, ONTARIO, CANADA.--DISCUSSION OF TURBIDITY AS IT RELATES TO CHEMICAL AND PHYSICAL PROCESSES IN RUNNING WATER AND THE DISTRIBUTION OF STREAM ORGANISMS. SILT DEPOSITION. SUSPENDED SEDIMENT. TURBIDITY. PHYTOPLANKTON. PERIPHYTON. MACROPHYTES. BENTHIC MACROINVERTEBRATES. FISH.

125 HYNES, H.B.N. 1970B. THE ECOLOGY OF FLOWING WATERS IN RELATION TO MANAGEMENT. J. WATER POLLUT. CONTROL FED. 42:418-424.--DISCUSSION OF SILT DISCHARGE CREATING LARGE, STABLE AREAS FOR WEED DEVELOPMENT. THE MACROPHYTES COMPLETELY ALTER THE SUBSTRATE (DIRECTLY AND INDIRECTLY) AND THUS, THE COMPOSITION AND DISTRIBUTION OF THE FAUNA. SILT DEPOSITION. SUSPENDED SEDIMENT. TURBIDITY. MACROPHYTES. BENTHIC MACROINVERTEBRATES.

126 HYNES, H.B.N. 1975. THE STREAM AND ITS VALLEY. VERH. INT. VEREIN. LIMNOL. 19:1-15.--DISCUSSION OF THE ADSORPTION OF ORGANIC MATTER ONTO SUSPENDED SEDIMENT. SUSPENDED SEDIMENT. TURBIDITY.

127 IRWIN, W.H., AND F.J. CLAFFEY. 1966. SOIL TURBIDITY, LIGHT PENETRATION AND PLANKTON POPULATIONS IN OKLAHOMA PONDS AND LAKES. PROC. OKLA. ACAD. SCI. 47:72-81.--ABOVE 25 PPM PHYTOPLANKTON AND ZOOPLANKTON ABUNDANCE WAS INVERSELY RELATED TO TURBIDITY. SEDIMENT DATA IN PPM. SUSPENDED SEDIMENT. TURBIDITY. PHYTOPLANKTON. ZOOPLANKTON.

128 IWAMOTO, R.N., E.O. SALO, M.A. MADEJ, R.L. MCCOMAS, AND R.L. RULIFSON. 1978. SEDIMENT AND WATER QUALITY: A REVIEW OF THE LITERATURE INCLUDING A SUGGESTED APPROACH FOR WATER QUALITY CRITERIA WITH SUMMARY OF WORKSHOP AND CONCLUSIONS AND RECOMMENDATIONS. EPA 910/9-78-048.--REVIEW OF EFFECTS OF SUSPENDED AND DEPOSITED SEDIMENT ON SALMONID FISHES. SILT DEPOSITION. SUSPENDED SEDIMENT. TURBIDITY. SALMONIDAE.

129 JENKINS, R.M. 1958. THE STANDING CROP OF FISH IN OKLAHOMA PONDS. PROC. OKLA. ACAD. SCI. 38:157-172.--DESCRIBES STANDING CROP OF FISH IN TURBID AND CLEAR PONDS. CONCLUDES THAT A 10 TO 30 POUND PER ACRE INCREASE COULD BE EXPECTED IF PONDS WERE CONSTRUCTED TO LIMIT SILTATION. SILT DEPOSITION. SUSPENDED SEDIMENT. TURBIDITY. CYPRINIDAE. ICTALURIDAE. CENTRARCHIDAE.

130 *JENSEN, A.L. 1971. THE EFFECTS OF INCREASED MORTALITY ON THE YOUNG IN A POPULATION OF BROOK TROUT, A HYPOTHETICAL ANALYSIS. TRANS. AM. FISH. SOC. 102:456-459.

131 JOHNSON, F.H. 1961. WALLEYE EGG SURVIVAL DURING INCUBATION ON SEVERAL TYPES OF BOTTOMS IN LAKE WINNIBIGOSHISH, MINNESOTA AND CONNECTING WATERS. TRANS. AM. FISH. SOC. 90:312-322.--WALLEYE EGGS ON SILTY BOTTOMS HAVE LOWER SURVIVAL THAN THOSE ON GRAVEL BOTTOMS. SEDIMENT DATA AS PARTICLE SIZES. SILT DEPOSITION. SUSPENDED SEDIMENT. TURBIDITY. PERCIDAE.

132 JONES, J.R., AND R.W. BACHMANN. 1978. A SURVEY OF WATER TRANSPARENCY IN IOWA LAKES. PROC. IOWA ACAD. SCI. 85:6-9.--IN 50 IOWA LAKES REDUCED TRANSPARENCY WAS RELATED MORE TO ALGAL DENSITY THAN TO SUSPENDED INORGANIC MATTER (SEDIMENT). SUSPENDED SEDIMENT. TURBIDITY. PHYTOPLANKTON.

133 JONES, J.R.E. 1964. FISH AND RIVER POLLUTION. BUTTERWORTHS, LONDON.--SUSPENDED COAL DUST CUTS OFF THE LIGHT FROM STREAMBED, PREVENTING PHOTOSYNTHESIS BY PLANTS AND REDUCING THE ABUNDANCE OF MACROINVERTEBRATES. SUSPENDED SEDIMENT. TURBIDITY. PHYTOPLANKTON. MACROPHYTES. BENTHIC MACROINVERTEBRATES.

134 *KAESLER, R.L., AND E.E. HERRICKS. 1977. ANALYSIS OF DATA FROM BIOLOGICAL SURVEYS OF STREAMS: DIVERSITY AND SAMPLE SIZE. WATER RES. BULL. NO 13.

135 KENNEDY, C. 1977. WILDLIFE CONFLICTS IN RIPARIAN MANAGEMENT: WATER. PP. 52-58 IN SYMPOSIUM ON IMPORTANCE, PRESERVATION AND MANAGEMENT OF RIPARIAN HABITATS. GEN. TECH. REP. RM-43. U.S. FOR. SERV.--TROUT IN SECTIONS OF AN OREGON STREAM WHERE THE WATERSHED WAS NOT SUBJECTED TO GRAZING BY CATTLE WERE 240 PERCENT MORE ABUNDANT THAN IN GRAZED SECTIONS RECEIVING HEAVY LOADS OF SILT. SILT DEPOSITION. SUSPENDED SEDIMENT. TURBIDITY. SALMONIDAE.

136 KING, D.L., AND R.C. BALL. 1964. THE INFLUENCE OF HIGHWAY CONSTRUCTION ON A STREAM. RES. REP. NO. 19., MICH. ST. UNIV. AGRIC. EXP. STATION, EAST LANSING, MICH.--A TWO-FOLD INCREASE IN INORGANIC SEDIMENTS (FROM HIGHWAY CONSTRUCTION) SUBSTANTIALLY REDUCED POPULATIONS OF BENTHIC INSECTS AND TUBIFICID WORMS. SMALLMOUTH BASS POPULATIONS DECREASED AS POOLS WERE FILLED BY SEDIMENT. SEDIMENT DATA AS ACCUMULATED DEPTH ON BOTTOM (MM). SILT DEPOSITION. SUSPENDED SEDIMENT. TURBIDITY. PERIPHYTON. AQUATIC INSECTS. BENTHIC MACROINVERTEBRATES. CENTRARCHIDAE.

137 *KITCHELL, J.F., J.F. KOONCE, R.V. O'NEILL, H.H. SHUGART, JR., J.J. MAGNUSON, AND R.S. BOOTH. 1974. MODEL OF FISH BIOMASS DYNAMICS. TRANS. AM. FISH. SOC. 103:786-798.

138 *KREBS, C.J. 1978. ECOLOGY: THE EXPERIMENTAL ANALYSIS OF DISTRIBUTION AND ABUNDANCE. HARPER AND ROW, NEW YORK.

139 LANGLOIS, T.H. 1941. TWO PROCESSES OPERATING FOR THE REDUCTION IN ABUNDANCE OR ELIMINATION OF FISH SPECIES FROM CERTAIN TYPES OF WATER AREAS. TRANS. SIXTH NORTH AM. WILDL. CONF. 1941:189-201.--LAND USE PRACTICES HAVE INCREASED SILT LOADS IN LAKE ERIE. DEPOSITION OF THIS SILT HAS DENUDED THE VEGETATION AND COVERED HARD SUBSTRATES, AND, THUS, GREATLY REDUCED THE NUMBERS OF FISHES, SUCH AS CISCOES, WHITEFISH AND YELLOW PERCH, WHICH REQUIRE SUCH AREAS TO BREED. FISH SUCH AS THE SAUGER, SHEEPSHEAD, CATFISHES AND CARP, WHICH TOLERATE TURBID WATER, ARE THRIVING UNDER PRESENT CONDITIONS. PRESENTS QUALITATIVE INFORMATION ONLY. TURBIDITY. SILT DEPOSITION. COREGONIDAE. PERCIDAE. SCIAENIDAE. ICTALURIDAE. CYPRINIDAE.

140 LARIMORE, R.W. 1975. VISUAL AND TACTILE ORIENTATION OF SMALLMOUTH BASS FRY UNDER FLOODWATER CONDITIONS. PP. 323-332 IN R.H. STROUD AND H. CLEPPER, EDS. BLACK BASS BIOLOGY AND MANAGEMENT. SPORT FISHING INST., WASH. D.C.--CONDITIONS WHICH SIMULATED RIVER FLOOD STAGES (RAPID CHANGES IN VELOCITY, TURBULENCE, AND TURBIDITY) CAUSED DOWNSTREAM DISPLACEMENT OF SMALLMOUTH BASS FRY AS A RESULT OF DISRUPTED VISUAL AND TACTILE ORIENTATION. FEWER FRY WERE DISPLACED IN CLEAR WATER (LESS THAN 10 JTU) THAN IN TURBID (250 AND 2350 JTU). SUSPENDED SEDIMENT. TURBIDITY. CENTRARCHIDAE.

141 *LEFKOVITCH. 1962. AN EXPERIMENTAL AND THEORETICAL APPROACH TO THE AGE STRUCTURE OF POPULATIONS OF CONTINUOUSLY BREEDING ANIMALS. XI INTERN. CONGR. ENT. VIENNA. 1960. II:309-313.

142 *LEFKOVITCH, L.P. 1965. THE STUDY OF POPULATION GROWTH IN ORGANISMS GROUPED BY STAGES. BIOMETRICS. 21:1-18.

143 *LEFKOVITCH, L.P. 1967. A THEORETICAL EVALUATION OF POPULATION GROWTH AFTER REMOVING INDIVIDUALS FROM SOME AGE GROUPS. BULL. ENT. RES. 57:437-445.

144 LEGORE, R.S., AND D.M. DESVOIGNE. 1973. ABSENCE OF ACUTE EFFECTS ON THREE-SPINE STICKLEBACKS (GASTEROSTEUSACULEATUS) AND COHO SALMON (ONCORHYNCHUS KISUTCH) EXPOSED TO RESUSPENDED HARBOR SEDIMENT CONTAMINANTS. J. FISH. RES. BOARD CAN. 30:1240-1242.--RESUSPENDED HARBOR SEDIMENT AT CONCENTRATIONS OF UP TO 5 PERCENT WET WEIGHT (28.8 G/L DRY WEIGHT) HAD NO OBSERVABLE EFFECT ON COHO SALMON FRY OR THREE-SPINE STICKLEBACKS IN 96 HOUR BIOASSAYS. THE SEDIMENTS WERE CONTAMINATED WITH HIGH LEVELS OF ORGANIC MATTER, OIL AND GREASE, ZINC, AND LEAD. SUSPENDED SEDIMENT. SALMONIDAE. GASTEROSTEIDAE.

145 *LESLIE. P.H. 1945. ON THE USE OF MATRICES IN CERTAIN POPULATION MATHAMATICS. BIOMETRIKA 33:183-212.

146 *LESLIE, P.H. 1948. SOME FURTHER NOTES ON THE USE OF MATRICES IN POPULATION MATHEMATICS. BIOMETRIKA 35:213-245.

147 LIEPOLT, R. 1961. BIOLOGISCHE AUSWIRKUNG DER ENTSCHLAMMUNG EINES HOCHGEBIRGSSTAUSCES IN EINEM ALPINEN FLIESSGEWASSER. WASS. ABWASS. 3:110-113.--THE TROUT FISHERY IN TWO NORWEGIAN STREAMS WITH AVERAGE SUSPENDED SEDIMENT CONCENTRATIONS OF 25 TO 50 PPM WAS NOT HARMED BY DREDGING OPERATIONS WHICH RAISED THE CONCENTRATION TO 160 PPM FOR SHORT PERIODS. SUSPENDED SEDIMENT. TURBIDITY. SALMONIDAE.

148 LOOSANOFF, V.L., AND F.D. TOMERS. 1948. EFFECT OF SUSPENDED SILT AND OTHER SUBSTANCES ON THE RATE OF FEEDING OF OYSTERS. SCIENCE 107:189-201.--THE ADDITION OF SILT IN SMALL QUANTITIES (SUCH AS 0.1 G/L) TO WATER BEING FILTERED BY OYSTERS CAUSED A 57% AVERAGE REDUCTION IN PUMPING RATE (AND THEREFORE IN FEEDING). SUSPENDED SEDIMENT. TURBIDITY. OSTREACEA.

149 *LORENZEN, M.W., AND C.W. CHEN. 1976. A CONCEPTUAL MODEL FOR ECOLOGICAL EVALUATION OF POWER PLANT COOLING SYSTEM OPERATION. PP. 794-798 IN W.R. OTT (ED.), ENVIROMENTAL MODELING AND SIMULATION. EPA 600/9-76-016.

150 LUEDTKE, R.J., AND M.A. BRUSVEN. 1976. EFFECTS OF SAND SEDIMENTATION ON COLONIZATION OF STREAM INSECTS. J. FISH. RES. BOARD CAN. 33:1881-1886.--DRIFTNETS, BASKET SAMPLERS, AND ARTIFICIAL STREAMS WERE USED TO DETERMINE INFLUENCE OF MINING SAND ACCUMULATIONS ON INSECT DRIFT, COLONIZATION AND UPSTREAM MOVEMENT. MANY COMMON RIFFLE INSECTS WERE UNABLE TO MOVE UPSTREAM ON SANDY SUBSTRATES AT FLOWS AS LOW AS 12 CM/S, BUT DOWNSTREAM MOVEMENT (DRIFTING AND CRAWLING) WAS GENERALLY SUCCESSFUL. SILT DEPOSITION. BENTHIC MACROINVERTEBRATES. AQUATIC INSECTS.

151 LUND, J.W.G. 1969. PHYTOPLANKTON. PP. 306-330 IN G.A. ROHLICH, ED. EUTROPHICATION: CAUSES, CONSEQUENCES, CORRECTIVES. NATL. ACAD. SCI. WASH.,D.C.--INCREASES IN SUSPENDED SEDIMENT BRINGS ABOUT REDUCTION IN LIGHT PENETRATION AND REDUCES THE PRIMARY PRODUCERS. SUSPENDED SEDIMENT. TURBIDITY. PHYTOPLANKTON.

152 *MACARTHUR, R. 1955. FLUCTUATIONS OF ANIMAL POPULATIONS AND A MEASURE OF COMMUNITY STABILITY. ECOLOGY 36:533-536.

153 MANSUETI, R.J. 1961. EFFECTS OF CIVILIZATION ON STRIPED BASS AND OTHER ESTUARINE BIOTA IN CHESAPEAKE BAY AND TRIBUTARIES. PROC. GULF CARIB. FISH INST. 14TH ANN. SESS. PP. 110-136.--IN ESTUARIES, STRIPED BASS EGGS AND LARVAE ARE SUSPENDED IN THE WATER COLUMN. LARVAE ARE ABLE TO UTILIZE THE ABUNDANT PLANKTON AND AVOID THE EFFECTS OF HIGH TURBIDITY AND SEDIMENTATION NEAR THE SUBSTRATE. SILT DEPOSITION. SUSPENDED SEDIMENT. TURBIDITY. PERCICHTHYIDAE.

154 MARCUSON, P.E. 1977. THE EFFECT OF CATTLE GRAZING ON BROWN TROUT IN ROCK CREEK, MONTANA. MONT. DEP. FISH GAME FED. AID PROJ. F-20-R-21-11A.--BROWN TROUT BIOMASS PER UNIT AREA IN A STREAM WITH A NONGRAZED WATERSHED WAS 340 PERCENT GREATER THAN IN AN ADJACENT GRAZED STREAM RECEIVING HEAVY SILT LOADS. SILT DEPOSITION. SUSPENDED SEDIMENT. TURBIDITY. SALMONIDAE.

155 *MARGALEF, R. 1968. PERSPECTIVES IN ECOLOGICAL THEORY. UNIV. CHICAGO PRESS, CHICAGO.

156 *MARGALEF, R. 1969. DIVERSITY AND STABILITY: A PRACTICAL PROPOSAL AND A MODEL OF INTERDEPENDENCE. PP. 25-37 IN G. WOODWELL AND H.H. SMITH (EDS.), DIVERSITY AND STABILITY IN ECOLOGICAL SYSTEMS. SYMPOSIUM IN BIOLOGY NO. 22, U.S. DEP. COMMERCE, SPRINGFIELD, VIRGINIA.

157 *MARSH, P.C., AND T.F. WATERS. 1980. EFFECTS OF AGRICULTURAL DRAINAGE DEVELOPMENT ON BENTHIC INVERTEBRATES IN UNDISTURBED DOWNSTREAM REACHES. TRANS. AM. FISH. SOC. 109:213-223.

158 MARZOLF, R.C. 1957. THE REPRODUCTION OF CHANNEL CATFISH IN MISSOURI PONDS. J. WILDL. MGT. 21:22-28.--PRODUCTION OF CHANNEL CATFISH WAS GREATER IN TURBID PONDS THAN IN CLEAR PONDS. HIGH LEVELS OF SUSPENDED SOLIDS PROVIDED CONCEALMENT FOR THE YOUNG BUT DID NOT INTERFERE WITH THEIR FEEDING SUCCESS. SUSPENDED SOLIDS. SUSPENDED SEDIMENT. TURBIDITY. ICTALURIDAE.

159 MATHERS, J.S. 1978. THE EFFECTS OF HIGHWAY CONSTRUCTION OF GALT CREEK, ONTARIO. VOLUMME I. ONT. MINIST. NAT. RESOURC., TORONTO, ONTARIO, CANADA.--MONITORED CREEK BEFORE AND AFTER CONSTRUCTION OF A HIGHWAY. CONSTRUCTION SEDIMENT WAS NOT DEPOSITED IN RIFFLE AREAS AND INVERTEBRATE ABUNDANCE DID NOT CHANGE. POOLS AND OTHER FISH HABITAT RECEIVED HEAVY SILT DEPOSITS AND FISH ABUNDANCE DECREASED. SEDIMENT DATA AS DEPTH ACCUMULATED ON BOTTOM. SILT DEPOSITION. SUSPENDED SEDIMENT. TURBIDITY. BENTHIC MACROINVERTEBRATES. SALMONIDAE.

160 *MATHIS, B.J. 1965. COMMUNITY STRUCTURE OF BENTHIC MACROINVERTEBRATES IN AN INTERMITTANT STREAM RECEIVING OIL FIELD BRINES. PH.D. THESIS, OKLAHOMA STATE UNIVERSITY, STILLWATER.

161 MATTSON, V.R., AND G.F. OLSON. 1978. THE EFFECTS OF SUSPENDED FINE PARTICLES (RED CLAY) ON THE AVAILABILITY AND TOXICITY OF METALS AND SYNTHETIC ORGANIC CHEMICALS TO FATHEAD MINNOWS. PROG. REP. N608-07, OFF. RES. DEV., EPA, DULUTH, MINN. (ABSTR.).--ONGOING RESEARCH TO DETERMINE ACUTE TOXICITY OF FATHEAD MINNOWS TO SEDIMENT-CARRIED METALS AND ORGANIC COMPOUNDS. NO DATA OR RESULTS GIVEN. SUSPENDED SEDIMENT. CYPRINIDAE.

162 MCCAFFERTY, W.P. 1978. PRE-MANAGEMENT ASSESSMENT OF AQUATIC MACROINVERTEBRATES IN A SMALL SEDIMENTARY DRAINAGE AREA OF THE MAUMEC AND LAKE ERIE BASIN. GREAT LAKES ENTOMOL. 11:37-43.--LOW SPECIES DIVERSITIES IN AREAS RECEIVING HEAVY AGRICULTURAL RUNOFF REFLECTED STRESSED CONDITIONS DUE TO HABITAT ELIMINATION CAUSED BY HEAVY SILT DEPOSITION. SEDIMENT DATA IN PPM. SILT DEPOSITION. SUSPENDED SEDIMENT. BENTHIC MACROINVERTEBRATES.

163 *MCCARTHY, L.T., AND W.B. KEIGHTON. 1964. QUALITY OF THE DELAWARE RIVER WATER AT TRENTON, NEW JERSEY. U.S. GEOL. SURV. WATER SUPP. PAP. 1779-X. WASHINGTON, D.C.

164 MCDONALD, J.G., AND M.P. SHEPARD. 1955. STREAM CONDITIONS AND SOCKEYE FRY PRODUCTION AT WILLIAMS CREEK. FISH. RES. BOARD CAN., PROG. REP. PACIF. COAST STATION NO. 104:34-37.--SILT DEPOSITION IN THE STREAM INCREASED SALMON EGG MORTALITY BY LIMITING INTERSTITIAL WATER FLOW AND OXYGEN. SILT DEPOSITION. SUSPENDED SEDIMENT. TURBIDITY. SALMONIDAE.

165 MCGAHA, Y.J. AND J.P. STEEN. 1974. THE EFFECTS OF VARIATIONS IN TURBIDITY ON CYCLES OF PLANKTONIC AND BENTHIC ORGANISMS IN FLOOD CONTROL RESERVOIRS OF NORTHERN MISSISSIPPI. PB-234437, NATL. TECH. INFOR. SERV., SPRINGFIELD, VA.--BENTHIC FAUNA IN MISSISSIPPI FLOOD CONTROL RESERVOIRS APPEARED TO BE MORE CLOSELY RELATED TO BOTTOM TYPE AND SUBMERGED VEGETATION THAN TO TURBIDITY. SUSPENDED SEDIMENT. TURBIDITY. BENTHIC MACROINVERTEBRATES.

166 *MCINTOSH, R.P. 1967. AN INDEX OF DIVERSITY AND THE RELATION OF CERTAIN CONCEPTS TO DIVERSITY. ECOLOGY 48:392-404.

167 MCKEE, J.E., AND H.W. WOLF. 1963. WATER QUALITY CRITERIA. CALF. ST. WATER QUAL. CONF. BOARD PUBL. 3-A.--REVIEW WHICH INCLUDES SEDIMENT EFFECTS ON PRIMARY PRODUCTIVITY, FISH FOOD ORGANISMS AND FISH. SILT DEPOSITION. SUSPENDED SEDIMENT. TURBIDITY. PHYTOPLANKTON. ZOOPLANKTON. BENTHIC MACROINVERTEBRATES. FISH.

168 MCLACHLAN, A.J., AND M.A. CANTRELL. 1976. SEDIMENT DEVELOPMENT AND ITS INFLUENCE ON THE DISTRIBUTION AND TUBE STRUCTURE OF CHIRONOMUS PLUMOSUS L. (CHIRONOMICAE, DIPTERA) IN A NEW IMPOUNDMENT. FRESHW. BIOL. 6:437-443.--FIELD AND LABORATORY EVIDENCE IS PRESENTED TO DEMONSTRATE THAT COLONIZATION OF A NEW IMPOUNDMENT BY THE EARLY INVADER, CHIRONOMUS PLUMOSUS L., IS STRONGLY INFLUENCED BY SEDIMENT. LARVAE AVOID AREAS WITH LITTLE SEDIMENT. SUCH AS ERODED OR NEWLY INNUNDATED SHORES. LARVAL ABUNDANCE WAS POSITIVELY CORRELATED WITH SEDIMENT DEPTH IN THE RANGE OF 0-10 MM. SILT DEPOSITION. SUSPENDED SEDIMENT. BENTHIC MACROINVERTEBRATES. CHIRONOMIDAE.

169 MCNEIL, W.J., AND W.H. AHNELL. 1964. SUCCESS OF PINK SALMON SPAWNING RELATIVE TO SIZE OF SPAWNING BED MATERIALS. U.S. FISH WILDL. SERV., SPEC. SCI. REPT. FISH NO. 469, 15PP.--SEDIMENT IN STREAM BED REDUCES RATE OF INTRAGRAVEL WATER FLOW AND THUS DISSOLVED OXYGEN AVAILABLE TO SALMONID EGGS. SALMON PRODUCTION IN MANY STREAMS S.E. ALASKA INVERSELY RELATED TO PERCENT OF STREAMBED MATERIAL GREATER THAN 0.833 MM IN DIAMETER. SILT DEPOSITION. SUSPENDED SEDIMENT. SALMONIDAE.

170 *MERRITT, R.W., AND K.W. CUMMINS. 1978. AN INTRODUCTION TO THE AQUATIC INSECTS OF NORTH AMERICA. KENDALL/HUNT PUBL. CO., DUBUQUE, IOWA.

171 MEYER, B.S., AND A.D. HERITAGE. 1941. EFFECT OF TURBIDITY AND DEPTH OF IMMERSION ON APPARENT PHOTOSYNTHESIS IN CERATOPHYLLUM DEMERSUM. ECOLOGY 22:17-22.--INCREASED TURBIDITY REDUCED PRIMARY PRODUCTIVITY. TURBIDITY DATA AS LIGHT PENETRATION. SUSPENDED SEDIMENT. TURBIDITY. PHYTOPLANKTON.

172 MILLER, R.J. 1975. COMPARATIVE BEHAVIOR OF CENTRARCHID BASSES. PP. 85-94 IN R.H. STROUD AND H. CLEPPER, EDS. BLACK BASS BIOLOGY AND MANAGEMENT. SPORT FISHING INSTIT., WASH., D.C.--FLUCTUATIONS OF LARGEMOUTH BASS POPULATIONS IN TURBID WATERS MAY BE DUE MORE TO THE INHIBITORY EFFECTS OF TURBIDITY ON MATING AND EGG SURVIVAL THAN UPON ANY DIRECT EFFECTS ON JUVENILES AND ADULTS. SILT DEPOSITION. SUSPENDED SEDIMENT. TURBIDITY. CENTRARCHIDAE.

173 MOORE, E. 1932. STREAM POLLUTION AS IT AFFECTS FISH LIFE. SEWAGE WKS. J. 4:159-165.--QUALITATIVE DISCUSSION OF THE EFFECTS OF SILT POLLUTION FROM GRAVEL-WASHING PLANTS ON MINNOWS. SILT DEPOSITION. SUSPENDED SEDIMENT. TURBIDITY. CYPRINIDAE.

174 MOORE, E. 1937. THE EFFECT OF SILTING ON THE PRODUCTIVITY OF WATERS. TRANS. NORTH AM. WILDL. CONF. 2:658-661.--DISCUSSES EFFECTS OF SUSPENDED AND DEPOSITED SILT ON PHYTOPLANKTON AND BENTHIC MACROINVERTEBRATES. SILT DEPOSITION. SUSPENDED SEDIMENT. TURBIDITY. PHYTOPLANKTON. BENTHIC MACROINVERTEBRATES.

175 MOORE, G.A. 1944. NOTES ON THE EARLY LIFE HISTORY OF NOTROPIS GIRARDI. COPEIA 1944:209-214.--SPAWNING HABITS AND LARVAL BEHAVIOR OF NOTROPIS GIRARDI SUGGEST ADAPTATIONS TO SILTY, GREAT PLAINS RIVER ENVIRONMENTS. TURBIDITY. SILT DEPOSITION. CYPRINIDAE.

176 MOORE, G.A. 1950. THE CUTANEOUS SENSE ORGANS OF BARBLED MINNOWS ADAPTED TO LIFE IN THE MUDDY WATERS OF THE GREAT PLAINS REGION. TRANS. AM. MICROSC. SOC. 69:69-95.--DISCUSSES EVOLUTIONARY ADAPTATIONS OF BARBLED MINNOWS LIVING IN TURBID WATERS. SUSPENDED SEDIMENT. TURBIDITY. CYPRINIDAE.

177 MORGAN, R.P., V.J. RASIN, JR., AND L.A. NOE. 1973. EFFECTS OF SUSPENDED SEDIMENTS ON DEVELOPMENT OF EGGS AND LARVAE OF STRIPED BASS AND YELLOW PERCH. NAT. RES. INST., UNIV. MARYLAND, REF. NO. 73-110.--PRESENTS RESULTS OF ACUTE BIOASSAYS ON STRIPED BASS AND WHITE PERCH LARVAE AND EGGS USING SUSPENDED SILT AND CLAY. ALSO REPORTS EFFECTS ON RATE OF DEVELOPMENT. SEDIMENT DATA IN PPM. SUSPENDED SEDIMENT. TURBIDITY. PERCICHTHYIDAE.

178 MORTON, J.W. 1977. ECOLOGICAL EFFECTS OF DREDGING AND DREDGE SPOIL DISPOSAL: A LITERATURE REVIEW. U.S. FISH WILDL. SERV. TECH. PAP. 94.--DISCUSSES EFFECTS OF DREDGING ON MACROPHYTES. SUSPENDED SEDIMENT. TURBIDITY. MACROPHYTES.

179 MUNCY. R.J. 1962. LIFE HISTORY OF THE YELLOW PERCH PERCA FLAVESCENS IN ESTUARINE WATERS OF SEVERN RIVER, A TRIBUTARY OF CHESAPEAKE BAY, MARYLAND. CHESAPEAKE SCI. 3:143-159.--HIGH EGG MORTALITY IN THE YELLOW PERCH WAS CORRELATED WITH INCREASED SILT DEPOSTION. SILT DEPOSITION. PERCIDAE.

180 MUNCY, R.J., G.J. ATCHISON, R.V. BULKEY, B.W. MENZEL, L.G. PERRY, AND R.C. SUMMERFELT. 1979. EFFECTS OF SUSPENDED SOLIDS AND SEDIMENT ON REPRODUCTION AND EARLY LIFE OF WARM WATER FISHES: A REVIEW. EPA-600/3-79-042. OFF. RES. DEV., CORVALLIS, OREGON.--REVIEW OF THE LITERATURE ON EFFECTS OF SEDIMENT ON WARM WATER FISH FROM 1930-1979. DISCUSSES THE DIFFERENT SUSCEPTIBILITIES OF DIFFERENT SPECIES AND LIFE STAGES, AND PAYS PARTICULAR ATTENTION TO REPRODUCTIVE BEHAVIOR. SILT DEPOSITION. SUSPENDED SEDIMENT. TURBIDITY. FISH.

181 MURPHY, G.I. 1962. EFFECT OF MIXING DEPTH AND TURBIDITY ON THE PRODUCTIVITY OF FRESHWATER IMPOUNDMENTS. TRAN. AM. FISH. SOC. 91:69-76.--DISCUSSES TURBIDITY AND SUSPENDED SEDIMENT IN RELATION TO NEGATIVE EFFECTS ON THE EFFECTIVE ENERGY AVAILABLE FOR PHOTOSYNTHESIS. SUSPENDED SEDIMENT. TURBIDITY. PHYTOPLANKTON.

182 NEAVE. F. 1947. NATURAL PROPOGATION OF CHUM SALMON IN A COASTAL STREAM. FISH. RES. BOARD. CAN., PROG. REP. PACIF. COAST STATION NO. 70:20-21.--SEDIMENT DEPOSITION CUT OFF THE OXYGEN SUPPLY TO CHUM SALMON EGGS. SILT DEPOSITION. SUSPENDED SEDIMENT. TURBIDITY. SALMONIDAE.

183 NEUMANN, D.A., J.M. O'CONNOR, J.A. SHERK, AND K.V. WOOD. 1975. RESPIRATORY AND HEMATOLOGICAL RESPONSES OF OYSTER TOAD FISH TO SUSPENDED SOLIDS. TRANS. AM. FISH. SOC. 104:775-781.--TOADFISH (OPSANUS TAU) HELD IN SUSPENSIONS OF FULLER'S EARTH AND RESUSPENDED NATURAL RIVER SEDIMENT EXHIBITED NO SIGNIFICANT CHANGES IN ERYTHROCYTE COUNT, HEMOGLOBIN CONCENTRATION, MICROHEMATOCRIT OR BLOOD OSMOLAL CONCENTRATIONS COMPARED WITH CONTROL FISH. SEDIMENT DATA IN G/L, AND GIVES PARTICLE SIZES. SUSPENDED SEDIMENT. TURBIDITY. BATRACHOIDIDAE.

184 *NIVEN, B.S. 1969. SIMULATION OF TWO INTERACTING SPECIES OF TRIBOLIUM. PHYSIOL. ZOOL. 42:248-255.

185 *NIVEN, B.S. 1970 MATHAMATICS OF POPULATIONS OF THE QUOKKA, SETONIX BRACHYURUS (MARSUPIALIA). I. A SIMPLE DETERMINISTIC MODEL FOR QUOKKA POPULATIONS. AUST. J. ZOOL. 18:209-214.

186 NUTTALL, P.M. 1972. THE EFFECTS OF SAND DEPOSITION UPON THE MACROINVERTEBRATE FAUNA OF THE RIVER CAMEL, CORNWALL. FRESHW. BIOL. 2:181-186.--SAND DEPOSITION IN A RIVER CAUSED IMPOVERISHMENT OF THE INVERTEBRATES. THIS EFFECT WAS DUE TO THE UNSTABLE SHIFTING NATURE OF THE SAND DEPOSITS RATHER THAN TO TURBIDITY OR ABRASION BY THE PARTICLES IN SUSPENSION. SILT DEPOSITION. SUSPENDED SEDIMENT. TURBIDITY. BENTHIC MACROINVERTEBRATES.

187 *OLIVE, J.H., AND K.R. SMITH. 1975. BENTHIC MACROINVERTEBRATES AS INDICES OF WATER QUALITY IN THE SCIOTIO RIVER BASIN, OHIO. BULL. OHIO BIOL. SURV. 5:124.

188 ORR, O.E. 1958. THE POPULATION OF FISHES AND LIMNOLOGICAL CONDITIONS OF HEYBURN RESERVOIR WITH REFERENCE TO PRODUCTIVITY. PH.D. THESIS, OKLA. STATE UNIV., STILLWATER.--RELATES TURBIDITY INCREASES TO LOWERED PHYTOPLANKTON AND GIZZARD SHAD ABUNDANCE IN AN OKLAHOMA RESERVOIR. SUSPENDED SEDIMENT. TURBIDITY. PHYTOPLANKTON. CLUPEIDAE.

189 OSCHWALD, W.R. 1972. SEDIMENT WATER INTERACTIONS. J. ENVIRON. QUAL. 1:360-366.--DISCUSSES EFFECTS OF TURBIDITY ON PRIMARY PRODUCTIVITY. SUSPENDED SEDIMENT. TURBIDITY. PHYTOPLANKTON.

190 PATRICK, R. 1972. AQUATIC COMMUNITIES AS INDICES OF POLLUTION. PP. 93-100 IN W.A. THOMAS, ED. INDICATORS OF ENVIRONMENTAL QUALILTY. PLENUM PRESS, N.Y., N.Y.--INCREASED TURBIDITY DECREASES LIGHT PENETRATION AND REDUCES THE POPULATON OF PRIMARY PRODUCERS. THIS REDUCTION CAUSES A SHIFT IN THE HETEROTROPHIC COMMUNITY FROM HERBIVORES TO THOSE THAT ARE PRIMARILY DETRITUS FEEDERS. SUSPENDED SEDIMENT. TURBIDITY. PHYTOPLANKTON.

191 PATRICK, R. 1976. THE IMPORTANCE OF MONITORING CHANGE. PP. 157-189 IN J. CAIRNS, JR., K.L. DICKSON AND G.F. WESTLAKE, EDS. BIOLOGICAL MONITORING OF WATER AND EFFLUENT QUALITY. ASTM SPEC. TECH. PUBL. NO. 607. AM. SOC. TEST. MAT., PHILADELPHIA, PA.--SEDIMENT TRAPPED BEHING CLARK HILL DAM ON THE SAVANNAH RIVER REDUCED THE SEDIMENT LOAD DOWNSTREAM FROM THE DAM, INCREASED THE DEPTH OF THE PHOTOSYNTHETIC ZONE, INCREASED THE ABUNDANCE OF PERIPHYTIC ALGAE, AND PRODUCED A LARGER NUMBER OF SPECIES OF BENTHIC ORGANISMS. SILT DEPOSITION. SUSPENDED SEDIMENT. TURBIDITY. PHYTOPLANKTON. PERIPHYTON. BENTHIC MACROINVERTEBRATES.

192 *PATTEN, B.C. 1962. SPECIES DIVERSTIY IN NET PHYTOPLANKTON OF RARITAN BAY. J. MAR. RES. 20:57-75.

193 *PAULET, M., H. KOHNKE, AND L.J. LUND. 1972. AN INTERPRETATION OF RESERVOIR SEDIMENTATION: I. EFFECT OF WATERSHED CHARACTERISTICS. J. ENVIRON. EVAL. 1:146-150.

194 *PEET, R.K. 1962. THE MEASUREMENT OF SPECIES DIVERSITY. ANN. REV. ECOL. SYST. 5:285-307.

195 *PENNAK, R.W. 1978 FRESH-WATER INVERTEBRATES OF THE UNITED STATES. JOHN WILEY AND SONS, NEW YORK.

196 *PENNYCUICK, C.J., R.M. COMPTON, AND L. BECKINGHAM. 1968. A COMPUTER MODEL FOR SIMULATING THE GROWTH OF A POPULATION OR OF TWO INTERACTING POPULATIONS. J. THEORET. BIOL. 18:316-329.

197 *PENNYCUICK, L. 1969. A COMPUTER MODEL OF THE OXFORD GREAT TIT POPULATION. J. THEORET. BIOL. 22:381-400.

198 PETERS, J.C. 1965. THE EFFECTS OF STREAM SEDIMENTATION ON TROUT EMBRYO SURVIVAL. PP. 275-279 IN BIOLOGICAL PROBLEMS IN WATER POLLUTION, THIRD SEMINAR, 1962. U.S. DEPT. HEW PUB. 999-WP-25.--SEDIMENT DEPOSITION LIMITS INTERSTITIAL WATER FLOW AND OXYGEN, DECREASING TROUT EGG SURVIVAL. SILT DEPOSITION. SUSPENDED SEDIMENT. TURBIDITY. SALMONIDAE.

199 PETERS, J.C. 1967. EFFECTS ON A TROUT STREAM FROM AGRICULTURAL PRACTICES. J. WILDL. MGT. 31:805-812.--GOOD POPULATIONS OF TROUT OCCURRED WHERE THE AVERAGE SEDIMENT LOAD VARIED FROM 134 TO 218 PPM DURING A TWO-YEAR PERIOD. LOW DENSITIES WERE FOUND FURTHER DOWNSTREAM WHERE THE SEDIMENT LOAD AVERAGED FROM 156 TO 324 PPM. EGG MORTALITY WAS HIGHER IN THE DOWNSTREAM STATIONS. SILT DEPOSITION. TURBIDITY. SALMONIDAE.

200 PETERS, J.C. 1972. EFFECTS OF SEDIMENT CONTROL ON FISH POPULATIONS. COLO. FISH. RES. REV. 1972:50-51.--REDUCTION IN SEDIMENT POLLUTION DUE TO EROSION CONTROL ON A MONTANA STREAM INFLUENCED THE ABILITY OF FISH SPECIES TO COMPETE FOR FOOD. WHITE SUCKERS, MOUNTAIN SUCKERS AND FLATHEAD CHUBS DECREASED IN CONDITION FACTOR. LOGNOSE SUCKERS EXPERIENCED INCREASED GROWTH INCREMENTS. BROWN TROUT SHOWED NO GROWTH CHANGES. SALMONIDAE. CYPRINIDAE. CATOSTOMIDAE.

201 *PIELOU, E.C. 1966. THE MEASUREMENT OF SPECIES DIVERSITY IN DIFFERENT TYPES OF BIOLOGICAL COLLECTIONS. J. THEORET. BIOL. 13:131-144.

202 *PIELOU, E.C. 1969. AN INTRODUCTION TO MATHAMATICAL ECOLOGY. JOHN WILEY AND SONS, NEW YORK.

203 PLATTS, W.S. 1979. LIVESTOCK GRAZING AND RIPARIAN STREAM ECOSYSTEMS - AN OVERVIEW. PP. 39-45 IN O.B. COPE, ED. PROC. FORUM GRAZING AND RIPARIAN STREAM ECOSYSTEMS. TROUT UNLIMITED, INC. BOISE, IDAHO.--STREAMS MODIFIED BY LIVESTOCK GRAZING ARE WIDER AND SHALLOWER, CONTAIN FINER SEDIMENT, BANKS ARE MORE UNSTABLE AND HAVE HIGHER SUMMER WATER TEMPERATURES THAN NATURAL STREAMS. SUMMARIZES LITERATURE ON LIVESTOCK RELATED WATERSHED EROSION AND FISH POPULATIONS AND SUGGESTS GRAZING AND FENCING STRATEGIES. SILT DEPOSITION. SUSPENDED SEDIMENT. TURBIDITY. SALMONIDAE.

204 PLATTS, W.S., AND W.F. MEGAHAN. 1975. TIME TRENDS IN RIVERBED SEDIMENT COMPOSITION IN SALMON AND STEELHEAD SPAWNING AREAS: SOUTH FORK SALMON RIVER, IDAHO. TRANS. 40TH NORTH AM. WILDL. CONF. PP. 229-239.--DISCUSSES PRE- AND POST-LOGGING ROAD CONSTRUCTION RIVERBED SEDIMENT SIZE COMPOSITION AND SALMONID SPAWNING. EXCESSIVE FINE SEDIMENT KILLED EMBRYOS AND FRY WITHIN THE CHANNEL SUBSTRATE BY REDUCING GRAVEL PERMEABILITY TO WATER AND THUS LIMITING OXYGEN AND CONCENTRATING TOXIC METABOLIC WASTES. SILT DEPOSITION. SUSPENDED SEDIMENT. SALMONIDAE.

205 PLATTS, W.S., M.A. SHIRAZI, AND D.H. LEWIS. 1979. SEDIMENT PARTICLE SIZES USED BY SALMON FOR SPAWNING WITH METHODS FOR EVALUATION. EPA 600/3-79-043, ENVIRN. RES. LAB., CORVALLIS, OREG.--USED GEOMETRIC MEAN PARTICLE DIAMETER METHOD TO DETERMINE SIZE COMPOSITION OF SUBSTRATES USED BY CHINOOK SALMON FOR SPAWNING IN A NORTHWESTERN U.S. RIVER. SEDIMENT SELECTED FOR SPAWNING RANGED FROM 7 TO 20 MM, BUT AVAILABLE SEDIMENT RANGED FROM 0.5 TO 100 MM IN DIAMETER. SILT DEPOSITION. SALMONIDAE.

206 *POLLARD, J.H. 1966. ON THE USE OF THE DIRECT MATRIX PRODUCT IN ANALYZING CERTAIN STOCHASTIC POPULATION MODELS. BIOMETRIKA 53:397-415.

207 RABENI, C.F., AND G.W. MINSHALL. 1977. FACTORS AFFECTING MICRODISTRIBUTION OF STREAM BENTHIC INSECTS. OIKOS 29:33-43.--STUDIED THE EFFECTS OF SUBSTRATE PARTICLE SIZE AND SILT DEPOSITIION ON BENTHIC INSECTS USING SUBSTRATUM FILLED TRAYS IN A STREAM. FLOW RATES WERE CONTROLLED. THE ADDITION OF A LIGHT COATING OF SILT (LESS THAN 1 MM DEEP) SIGNIFICANTLY REDUCED THE NUMBERS OF THREE SPECIES. SILT DEPOSITION. SUSPENDED SEDIMENT. TURBIDITY. BENTHIC MACROINVERTEBRATES. AQUATIC INSECTS.

208 REED, J.R. 1976. AN EVALUATION OF FISH AND MACROBENTHOS POPULATION RESPONSE TO SILT AND SEDIMENT FROM ROAD CONSTRUCTION ACTIVITY. WRRC BULL. 97, DEPT. BIOL., VA. COMMONWEALTH UNIV., NORFOLK, VA.--COMMUNITY RESPONSE TO SILTATION FROM HIGHWAY CONSTRUCTION WAS EVALUATED ON THE BASIS OF COMMUNITY DIVERSITY AND SPECIES ABUNDANCE. THERE WAS A REDUCTION IN NUMBERS OF SPECIES AND TOTAL ABUNDANCE OF BOTH BENTHOS AND FISH DOWNSTREAM FROM THE CONSTRUCTION AREA. DATA SUGGESTS THAT DRIFT WAS THE PRIMARY RESPONSE OF BENTHOS. SILT DEPOSITION. SUSPENDED SEDIMENT. TURBIDITY. FISH. BENTHIC MACROINVERTEBRATES.

209 *REIGER, H.A., AND H.F. HENDERSON. 1973. TOWARDS A BROAD ECOLOGICAL MODEL OF FISH COMMUNITIES AND FISHERIES. TRANS. AM. FISH. SOC. 102:56-72.

210 REIS, P.A. 1969. EFFECTS OF INORGANIC LIMESTONE SEDIMENT AND SUSPENSION ON THE EGG AND FRY OF BRACHYDANIO RERIOR. M.A. THESIS, DEPAUW UNIV., IND.--EGGS OF THE ZEBRA FISH HATCHED MORE QUICKLY IN SUSPENSIONS OF LIMESTONE DUST OF 18,000 TO 30,000 PPM. BUT DID NOT EXPERIENCE GREATER MORTALITY THAN CONTROLS. NEWLY HATCHED FRY, HOWEVER, DIED WITHIN FOUR HOURS IN SUSPENSIONS GREATER THAN 4800 PPM. SUSPENDED SEDIMENT. TURBIDITY. CYPRINIDAE.

211 *RIGGINS, R.E., AND E.D. SMITH. 1979. AQUATIC RATIONAL THRESHOLD VALUE (RTV) CONCEPTS FOR ARMY ENVIRONMENTAL IMPACT ASSESSMENT. U.S. ARMY CONSTR. ENG. RES. LAB., CERL-TR-N-74. CHAMPAIGN, ILLINOIS.

212 RITCHIE, J.C. 1972. SEDIMENT, FISH AND FISH HABITAT. J. SOIL WATER CONSERV. 27:124-125.--REVIEWS EFFECTS OF TURBIDITY ON FISH POPULATION CHANGES IN LAKE ERIE. FISH COMMUNITY CHANGED FROM CISCOES, WHITEFISH AND YELLOW PERCH TO SAUGER, SHEEPSHEAD, CATFISH AND CARP PARTLY BECAUSE OF SEDIMENT. SILT DEPOSITION. SUSPENDED SEDIMENT. TURBIDITY. COREGONIDAE. PERCIDAE. SCIAENIDAE. ICTALURIDAE.

213 ROBBINS, J.W.D., D.H. HOWELLS, AND G.J. KRIZ. 1971. ROLE OF ANIMAL WASTES IN AGRICULTURAL LAND RUNOFF. EPA WATER POLLUT. CONTROL RES. SER. 13020 DGX 08/71.--EROSION SILT REDUCED MUSSEL FEEDING TIME BY 75% AND CAUSED REPRODUCTIVE FAILURE AMONG SMALLMOUTH BASS. SILT DEPOSITION. SUSPENDED SEDIMENT. TURBIDITY. UNIONIDAE. CENTRARCHIDAE.

214 ROBEL, R.J. 1961. WATER DEPTH AND TURBIDITY IN RELATION TO GROWTH OF SAGO PONDWEED. J. WILDL. MGT. 25:436-438.--REPORTS AN INVERSE CORRELATION BETWEEN TURBIDITY AND PRODUCTION OF SAGO PONDWEED (POTAMOGETON PECTINATUS). TURBIDITY DATA IN COLORIMETRIC UNITS. SUSPENDED SEDIMENT. TURBIDITY. MACROPHYTES.

215 ROBINSON, A.R. 1971. SEDIMENT: OUR GREATEST POLLUTANT. AGRIC. ENG. 53: 406-408.--STATISTICS ON SEDIMENT SOURCES, LOADS, TOXIC MATERIALS AND ECONOMIC LOSSES. SILT DEPOSITION. SUSPENDED SEDIMENT. TURBIDITY.

216 ROGERS, B.A. 1969. TOLERANCE LEVELS OF FOUR SPECIES OF ESTUARINE FISHES TO SUSPENDED MINERAL SOLIDS. M.S. THESIS. UNIV. RHODE ISLAND.--REPORTS LC50 VALUES FOR FOUR ESTUARINE FISHES RANGING FROM 4 TO 300 G/L SUSPENDED SOLIDS. SUSPENDED SEDIMENT. TURBIDITY. GASTEROSTEIDAE.

217 ROGERS, G.E. 1976. VERTICAL BURROWING AND SURVIVAL OF SPHAERIID CLAMS UNDER ADDED SUBSTRATES IN POOL 19, MISSISSIPPI RIVER. IOWA ST. J. RES. 51:1-12.--FINGERNAIL CLAMS COULD WITHSTAND HEAVY DEPOSITS OF SILT BUT LESS SAND. SILT DEPOSITION. SUSPENDED SEDIMENT. TURBIDITY. SPHAERIIDAE.

218 ROSENBERG, D.M., AND A.P. WEINS. 1975. EXPERIMENTAL SEDIMENT ADDITION STUDIES ON THE HARRIS RIVER, N.W.T., CANADA: THE EFFECT ON MACRO-INVERTEBRATE DRIFT. VERH. INT. VEREIN. LIMNOL. 19:1568-1574.--THE NUMBER OF CHIRONOMIDAE CAUSED TO DRIFT BY THE ADDITION OF RIVER BANKSIDE SEDIMENT ALWAYS INCREASED WITH SEDIMENT ADDITION, BUT EPHEMEROPTERA , SIMULIIDAE, AND THE HYDRACARINA WERE INCONSISTENT IN THEIR DRIFT RESPONSE TO SUSPENDED SEDIMENT. SEDIMENT DATA IN MG/L. SUSPENDED SEDIMENT. TURBIDITY. BENTHIC MACROINVERTEBRATES.

219 SAUNDERS, J.W., AND M.W. SMITH. 1965. CHANGES IN STREAM POPULATION OF TROUT ASSOCIATED WITH INCREASED SILT. J. FISH. RES. BOARD CAN. 22:395-404.--LOW STANDING CROPS OF BROOK TROUT WERE CLOSELY ASSOCIATED WITH THE AMOUNT OF SILT DEPOSITION. SILTING DESTROYED HIDING PLACES AND CURTAILED SPAWNING. SEDIMENT DATA AS SILT DEPTH ON STREAM BOTTOM. SILT DEPOSITION. SALMONIDAE.

220 SAWYER, R.T. 1974. LEECHES (ANNELIDA: HIRUDINEA). PP. 82-136 IN C.W. HART AND S.L.H. FULLER, EDS. POLLUTION ECOLOGY OF FRESHWATER INVERTEBRATES. ACADEMIC PRESS, N.Y.--LAB STUDY DEMONSTRATED THAT PARASITIC LEECHES MAY BE AN INDICATOR OF SILT POLLUTION BECAUSE TURBIDITY DECREASES NATURAL PREDATION RATES BY FISH. INCLUDES SOME LITERATURE REVIEW. SUSPENDED SEDIMENT. TURBIDITY. HIRUDINEA. CENTRARCHIDAE.

221 SCHNEBERGER, E., AND M.E. JEWELL. 1928. FACTORS AFFECTING POND FISH PRODUCTION. KANS. FOR. FISH GAME COMM., BULL. 9:5-14.--LOW TURBIDITY WAS CORRELATED WITH HIGH FISH PRODUCTION. TURBIDITY IN PPM. FISH PRODUCTION AS NUMBER OF FISH PER ACRE. FISH SPECIES NOT GIVEN. TURBIDITY. FISH.

222 SCHUBEL, J.R., A.H. AULD, AND G.M. SCHMIDT. 1973. EFFECTS OF SUSPENDED SEDIMENT ON THE DEVELOPMENT AND HATCHING SUCCESS OF YELLOW PERCH AND STRIPED BASS EGGS. PROC. ANN. CONF. SOUTHEASTERN ASSOC. GAME FISH. COMM. 27:689-694.--CONCENTRATIONS OF 1000 MG/L OF NATURAL FINE-GRAINED SEDIMENT CAUSED A STATISTICALLY SIGNIFICANT INCREASE IN MORTALITY OF YELLOW PERCH AND STRIPED BASS EGGS. SILT DEPOSITION. SUSPENDED SEDIMENT. TURBIDITY. PERCIDAE. PERCICHTHYIDAE.

223 *SHANNON, C.E., AND W. WEAVER. 1963. THE MATHAMATICAL THEORY OF COMMUNICATION. UNIV. ILLINOIS PRESS, URBANA.

224 SHAPELY, S.P., AND D.M. BISHOP. 1965. SEDIMENTATION IN A SALMON STREAM. J. FISH. RES. BOARD CAN. 22:919-928.--TREATED RIFFLE AREAS WITH VARIOUS CONCENTRATIONS OF SUSPENDED SEDIMENT. INORGANIC SEDIMENT SETTLED OUT FASTER THAN ORGANIC. SEDIMENTATION DID NOT REDUCE INTRAGRAVEL DISSOLVED OXYGEN LEVELS OR SALMON PRODUCTION. SEDIMENT DATA IN PPM. SUSPENDED SEDIMENT. TURBIDITY. SALMONIDAE.

225 SHAPOVALOV, L., AND W. BERRIAN. 1940. AN EXPERIMENT IN HATCHING SILVER SALMON ONCORHYNCHUS KISUTCH EGGS IN GRAVEL. TRANS. AM. FISH. SOC. 69:135-140.--INCREASED CONCENTRATIONS OF DEPOSITED SEDIMENT DECREASED SALMON HATCHING BY DECREASING INTERSTITIAL WATER FLOW AND, THUS, AVAILABLE OXYGEN. SILT DEPOSITION. SUSPENDED SEDIMENT. TURBIDITY. SALMONIDAE.

226 SHAW, P.A., AND J.A. MAGA. 1943. THE EFFECT OF MINING SILT ON YIELD OF FRY FROM SALMON SPAWNING BEDS. CALIF. FISH GAME 29:29-41.--MINE SILT DEPOSITED ON GRAVEL SALMON SPAWNING BEDS DURING EITHER THE EARLY OR LATER STAGES OF INCUBATION RESULTED IN NEGLIGIBLE YIELDS OF FRY. THE SILT FORMS A COATING WHICH PRESERVES THE EGGS AND PREVENTS DEVELOPMENT OF THE FRY. SEDIMENT DATA IN PPM. NUMERICAL DATA ON HATCHING RATES. MINE SILT. SALMONIDAE.

227 SHELTON, J.M., AND R.D. POLLOCK. 1966. SILTATION AND EGG SURVIVAL IN INCUBATION CHANNELS. TRANS. AM. FISH SOC. 95:183-187.--FALL-CHINOOK SALMON EGGS IN INCUBATION CHANNELS SUFFERED AS MUCH AS 85% MORTALITY WHEN 15 TO 30% OF THE VOIDS IN THE GRAVEL WERE FILLED WITH SEDIMENT. WITH ONE 70 FOOT SECTION OF THE CHANNEL USED AS A SILT-SETTLING BASIN, THE MORTALITY WAS REDUCED TO 10% OR LESS. SILT DEPOSITION. SUSPENDED SEDIMENT. SALMONIDAE.

228 SHERK, J.A., JR. 1972. CURRENT STATUS OF THE KNOWLEDGE OF THE BIOLOGICAL EFFECTS OF SUSPENDED AND DEPOSITED SEDIMENTS IN CHESAPEAKE BAY. CHESAPEAKE SCI. 13:5137-5144.--REVIEWS EFFECTS OF SUSPENDED AND DEPOSITED SEDIMENTS FROM FLOODS, STORMS AND DREDGING OPERATIONS ON ESTUARINE FISHES. SILT DEPOSITION. SUSPENDED SEDIMENT. TURBIDITY. FISH.

229 SHERK, J.A., JR., J.M. O'CONNOR, AND D.A. NEUMANN. 1976. EFFECTS OF SUSPENDED AND DEPOSITED SEDIMENTS ON ESTUARINE ENVIRONMENTS. RECENT ADVAN. ESTUAR. RES., PROC. II INT. CONF. ON ESTUAR. RES. ACADEMIC PRESS, N.Y., N.Y.--OBSERVED INCREASES IN WHITE PERCH HEMOGLOBIN CONCENTRATION, MICROHEMATOCRIT, AND ERYTHROCYTE COUNT AFTER FIVE-DAY EXPOSURE TO 0.65 G/L SUSPENDED FULLER'S EARTH. SUSPENDED SEDIMENT. PERCICHTHYIDAE.

230 SHERK, J.A., JR., J.M. O'CONNOR, R.D. PRINCE, AND K.V. WOOD. 1974. EFFECTS OF SUSPENDED AND DEPOSITED SEDIMENTS ON ESTUARINE ORGANISMS, PHASE II. UNIV. MD. NAT. RESOUR. INST. REF. NO. 74-20.--TESTED 14 ESTUARINE FISHES FOR TOLERANCE TO SUSPENSIONS OF FULLER'S EARTH, KAOLINITE AND NATURAL MUDS. LD50 VALUES VARIED FROM LESS THAN 1 G/L TO APPROXIMATELY 200 G/L: SENSITIVITY WAS FOUND TO BE RELATED TO A SPECIES HABITAT PREFERENCE AND LEVEL OF ACTIVITY. ALSO PRESENTS HEMATOLOGICAL RESPONSE. SUSPENDED SEDIMENT. TURBIDITY. BATRACHOIDIDAE. CYPRINODONTIDAE. PERCICHTHYIDAE. SOLEIDAE.

231 *SMITH, F.E. 1963. POPULATION DYNAMICS IN DAPHNIA MAGNA AND A NEW MODEL FOR POPULATION GROWTH. ECOLOGY 44:551-663.

232 SMITH, F.E. 1976. WATER DEVELOPMENT IMPACT ON FISH RESOURCES AND ASSOCIATED VALUES OF THE TRINITY RIVER, CALIFORNIA. PP. 98-111 IN J.F. OSBORN AND C.H. ALLMAN, EDS. PROCEEDINGS, INSTREAM FLOW NEEDS, VOL. II. AM. FISH. SOC., BETHESDA, MARYLAND.--INCREASED TURBIDITY AND SILT DEPOSITION RESULTING FROM THE TRINITY RIVER PROJECT CONSTRUCTION HAS REDUCED STEELHEAD AND SALMON MIGRATION AND LIVING AND SPAWNING HABITATS. SEDIMENT INFORMATION QUALITATIVE. FISH DATA AS CREEL CENSUS AND NUMBER RETURNING TO HATCHERY. SILT DEPOSITION. TURBIDITY. SALMONIDAE.

233 SMITH, H.G., R.K. BURNARD, E.E. GOOD, AND J.M. KEENER. 1973. RARE AND ENDANGERED VERTEBRATES OF OHIO. OHIO J. SCI. 73:257-271.--SURVEY WHICH IDENTIFIES SILTATION OF SPAWNING HABITAT AS A MAJOR CONTRIBUTOR TO DECIMATION OF WARMWATER FISH POPULATIONS IN THE MIDWEST. SILT DEPOSITION. SUSPENDED SEDIMENT.

234 SMITH, O.R. 1940. PLACER MINING SILT AND ITS RELATION TO SALMON AND TROUT ON THE PACIFIC COAST. TRANS. AM. FISH. SOC. 69:225-230.--INCREASED TURBIDITY LED TO RETARDATION AND IN SOME CASES ELIMINATION OF SPAWNING ACTIVITIES. INDICATES THAT TURBIDITY CAUSED A REDUCTION OF POPULATION LEVELS, BUT DOES NOT GIVE NUMBERS OR PPM. TURBIDITY. SALMONIDAE.

235 SMITH, P.W. 1971. ILLINOIS STREAMS: A CLASSIFICATION BASED ON THEIR FISHES AND AN ANALYSIS OF FACTORS RESPONSIBLE FOR DISAPPEARANCE OF NATIVE SPECIES. ILL. NAT. HIST. SURV. BIOL. NOTES NO. 76.--SURVEY WHICH IDENTIFIES SILTATION OF SPAWNING HABITAT AS A MAJOR CONTRIBUTOR TO DECIMATION OF WARMWATER FISH POPULATIONS IN THE MIDWEST. SILT DEPOSITION. SUSPENDED SEDIMENT. TURBIDITY. MACROPHYTES. FISH.

236 SMITH, W.M., AND J.W. SAUNDERS. 1958. MOVEMENTS OF BROOK TROUT, SALVELINUS FONTINALIS, (MITCHELL) BETWEEN AND WITHIN FRESH AND SALT WATER. J. FISH. RES. BOARD CAN. 15:1403-1449.--HIGH CONCENTRATIONS OF SUSPENDED SEDIMENT DID NOT SEEM TO IMPEDE UPSTREAM MIGRATIONS OF TROUT AND SALMON. SEDIMENT DATA IN PPM. SUSPENDED SEDIMENT. TURBIDITY. SALMONIDAE.

237 *SONLEITNER, F.J. 1977. A STOCHASTIC COMPUTER MODEL FOR SIMULATING POPULATION GROWTH. RES. POP. ECOL. 19:10-31.

238 SORENSEN, D.L., M.M. MCCARTHY, E.J. MIDDLEBROOKS, AND D.B. PORCELLA. 1977. SUSPENDED AND DISSOLVED SOLIDS EFFECTS ON FRESHWATER BIOTA: A REVIEW. EPA-600/3-77-042. U.S.E.P.A., CORVALLIS, OREGON.--REVIEW OF THE RECENT LITERATURE ON THE EFFECTS OF SUSPENDED AND DISSOLVED SOLIDS. CONCLUDES THAT MAJOR RESEARCH IS NEEDED IN THE AREA OF COMMUNITY RESPONSE TO THESE LOADS, ESPECIALLY TO THE PHOTOSYNTHETIC AND MICRO- AND MACROINVERTEBRATE LEVELS. SUSPENDED SOLIDS. SUSPENDED SEDIMENT. TURBIDITY. PHYTOPLANKTON. MACROPHYTE. MICROINVERTEBRATE. ZOOPLANKTON. BENTHIC MACROINVERTEBRATES. FISH.

239 SPOON, D.M. 1975. SURVEY, ECOLOGY, AND SYSTEMATICS OF THE UPPER POTOMAC ESTUARY BIOTA: AUFWUCHS MICROFAUNA, PHASE I. PROJ. NO. B-002-DC., WATER RESOURCES RESEARCH CENTER. WASH. TECH. INSTIT., WASH., D.C.--DECREASED TURBIDITY MAY HAVE BEEN A FACTOR LEADING TO A DOUBLING IN THE NUMBER OF MICROMETAZOAN SPECIES COLONIZING ARTIFICIAL SUBSTRATES IN THE UPPER POTOMAC ESTUARY BELOW A SEWAGE TREATMENT PLANT IN 1974 AS CONTRASTED TO 1971. SUSPENDED SEDIMENT. TURBIDITY. PERIPHYTON. PROTOZOA.

240 SPOON, D.M. 1976. SURVEY AND ECOLOGY OF AUFWUCH PROTOZOA AND MICROMETAZOA OF THE POTOMAC ESTUARY 1971 AND 1974. J. PROTOZOOL. 23:25.--DECREASED TURBIDITY MAY HAVE BEEN A FACTOR LEADING TO A DOUBLING IN THE NUMBER OF PROTOZOAN AND ALGAL SPECIES COLONIZING ARTIFICIAL SUBSTRATES IN THE UPPER POTOMAC ESTUARY BELOW A SEWAGE TREATMENT PLANT IN 1974 AS CONTRASTED TO 1971. SUSPENDED SEDIMENT. TURBIDITY. PERIPHYTON. PROTOZOA.

241 STANLEY, J.G., W.W. MILEY II, AND D.L. SUTTON. 1978. REPRODUCTIVE REQUIREMENTS AND THE LIKELIHOOD FOR NATURALIZATION OF ESCAPED GRASS CARP IN THE UNITED STATES. TRANS. AM. FISH. SOC. 107:119-128.--FEEDING EFFICIENCY OF THE EARLIEST STAGES OF GROWTH OF THE GRASS CARP WAS FOUND TO BE RELATED TO THE AMOUNT OF ILLUMINATION. THE MINIMUM NUMBER OF PLANKTONIC FOOD ORGANISMS REQUIRED TO SUPPORT A FEEDING LARVA IN CLEAR WATER WAS 1000 PER LITER, WHILE 2000-2500 PER LITER WERE REQUIRED IN POORLY ILLUMINATED WATER. SUSPENDED SEDIMENT. TURBIDITY. ZOOPLANKTON. CYPRINIDAE.

242 STARRETT, W.C. 1951. SOME FACTORS AFFECTING THE ABUNDANCE OF MINNOWS IN THE DES MOINES RIVER, IOWA. ECOLOGY 32:13-37.--SUGGESTS THAT THE COMBINATION OF FLOODS AND HEAVY SILT LOADS ARE AN IMPORTANT LIMITING FACTOR FOR MINNOWS IN THE DES MOINES RIVER. THESE FACTORS CAUSE AN ELIMINATION OF POSSIBLE SPAWNING SITES WHICH MAY POSTPONE SPAWNING OR RESULT IN THE RESORPTION OF EGGS AND A DISINCLINATION TO SPAWN. SILT DEPOSITION. SUSPENDED SEDIMENT. TURBIDITY. CYPRINIDAE.

243 STEWART, T.A. 1953. SPAWNING MIGRATION, REPRODUCTION AND YOUNG STAGES OF THE LOCH TROUT (SALMO TRUTTA L.). FRESHW. SALMON FISH. RES. 5:1-39.--IN LABORATORY INVESTIGATIONS, NEWLY HATCHED BROWN TROUT WERE CAPABLE OF SLOUGHING SOLID PARTICLES FROM THEIR GILLS IN MUCOUS-LIKE SECRETIONS. CONTINUOUS ADDITIONS OF SEDIMENT, EVENTUALLY EXCEEDING 1 MM IN DEPTH, CAUSED INFLATION OF THE GILL MEMBRANE WHICH RESULTED IN DEATH. SILT DEPOSITION. SUSPENDED SEDIMENT. SALMONIDAE.

244 STOUT, V.M. 1978. EFFECTS OF DIFFERENT SILT LOADS AND OF HYDRO-ELECTRIC DEVELOPMENT ON FOUR LARGE LAKES. VERH. INT. VEREIN. LIMNOL. 20:1182-1185.--DISCUSSES EFFECTS OF VARYING SILT LOADS IN OTHERWISE SIMILIAR RESERVOIRS ON PHYTOPLANKTON AND ZOOPLANKTON ABUNDANCE. SUSPENDED SEDIMENT. TURBIDITY. PHYTOPLANKTON. ZOOPLANKTON.

245 SUMNER, F.H., AND O.R. SMITH. 1940. HYDRAULIC MINING AND DEBRIS DAMS IN RELATION TO FISH LIFE IN THE AMERICAN AND YUBA RIVERS OF CALIFORNIA. CALIF. FISH GAME 26:2-22.--MUDDY WATER DISCOURAGES SALMON SPAWNING. CLEAN STREAM-BOTTOMS PRODUCE MORE FISH-FOOD ORGANISMS THAN SILTED BOTTOMS. TURBIDITY. SILT DEPOSITION. SALMONIDAE. BENTHIC MACROINVERTEBRATES.

246 SURBER, E.W. 1969. SMALLMOUTH BASS STREAM INVESTIGATIONS, SHENANDOAH RIVER SURVEY. VA. COMM. GAME INLAND FISH. PROJ. REP. F-014-R-09.--TURBIDITIES MUST DECLINE TO APPROXIMATELY 5-10 JTU BEFORE SMALLMOUTH BASS WILL SPAWN IN OTHERWISE SUITABLE AREAS. SUSPENDED SEDIMENT. TURBIDITY. CENTRARCHIDAE.

247 SWALE, E.M.F. 1964. A STUDY OF THE PHYTOPLANKTON OF A CALCAREOUS RIVER. J. ECOL. 52:433-446.--RATES OF FLOW AND TURBIDITY WERE THE MAJOR FACTORS LIMITING ALGAL PRODUCTIVITY IN THE RIVER LEE. TURBIDITY. PHYTOPLANKTON.

248 SWENSON, W.A. 1978. INFLUENCE OF TURBIDITY ON FISH ABUNDANCE IN WESTERN LAKE SUPERIOR. EPA, OFF. RES. DEV., RES. REP. EPA-600/3-78-067.--LABORATORY AND FIELD STUDY OF THE INFLUENCE OF RED CLAY TURBIDITY ON PREDATOR-PREY RELATIONS IN THE WESTERN LAKE SUPERIOR FISH COMMUNITY. TURBIDITY. ZOOPLANKTON. SALMONIDAE. OSMERIDAE. PERCIDAE.

249 SWENSON, W.A., AND M.L. MATSON. 1976. INFLUENCE OF TURBIDITY ON SURVIVAL, GROWTH AND DISTRIBUTION OF LARVAL LAKE HERRING (COREGONUS ARTEDII). TRANS. AM. FISH. SOC. 105:541-545.--LAB STUDIES WERE CARRIED OUT TO DETERMINE THE INFLUENCE OF RED-CLAY TURBIDITY ON LARVAL LAKE HERRING. GROWTH AND SURVIVAL WERE NOT INFLUENCED AT THE RANGE OF CONCENTRATIONS STUDIED (1-28 PPM). LARVAE IN THE HIGHER SUSPENSIONS WERE DISTRIBUTED CLOSER TO THE SURFACE OF THE TEST CHAMBERS. SUSPENDED SOLIDS DATA AS PPM OR FTV. FISH DATA AS MORTALITY AND WEEKLY GROWTH INCREMENTS (MM). TURBIDITY. SALMONIDAE.

250 SWINGLE, H.S. 1956. APPRAISAL OF METHODS OF FISH POPULATION STUDY. PART IV: DETERMINATION OF BALANCE IN FARM FISH PONDS. TRANS. NORTH AM. WILDL. CONF. 21:298-318.--LARGEMOUTH BASS AND BLUEGILL SPAWN EARLIER IN CLEAR WATER THAN IN WATERS COLORED BY PHYTOPLANKTON OR SUSPENDED CLAY. BULLHEAD CATFISH REPRODUCED SUCCESSFULLY IN MUDDY PONDS. SUSPENDED SEDIMENT. TURBIDITY. CENTRARCHIDAE. ICTALURIDAE.

251 SYKORA, J.L., E.J. SMITH, AND M. SYNAK. 1972. EFFECT OF LIME NEUTRALIZED IRON HYDROXIDE SUSPENSIONS ON JUVENILE BROOK TROUT (SALVELINUS FONTINALIS, MITCHELL). WATER RES. 6:935-950.--VARIED SUSPENSIONS OF IRON HYDROXIDE WERE CORRELATED WITH WEIGHT OF JUVENILE BROOK TROUT. IT WAS ASSUMED THAT IMPAIRED VISIBILITY DUE TO HIGH TURBIDITY PREVENTED THE FISH FROM FEEDING WHICH IN TURN RESULTED IN SLOWER GROWTH. TURBIDITY DATA AS MG/L OR JTU. SUSPENDED SEDIMENT. TURBIDITY. SALMONIDAE.

252 TARZWELL, C.M., AND A.R. GAUFIN. 1953. SOME IMPORTANT BIOLOGICAL EFFECTS OF POLLUTION OFTEN DISREGARDED IN STREAM SURRVEYS. PURDUE UNIV. ENG. BULL., PROC. 8TH ANN. WASTE CONF. PP. 295-316.--RANKED DIFFERENT SUBSTRATES ON THEIR ABILITY TO SUPPORT MACROINVVERTEBRATE POPULATIONS. SHIFTING SAND SUPPORTED THE FEWEST NUMBER OF ORGANISMS AND VARIOUS SUBTRATES MIXED WITH SILT WERE RANKED LOW. SILT DEPOSITION. SUSPENDED SEDIMENT. TURBIDITY. BENTHIC MACROINVERTEBRATES.

253 *TAYLOR, N.W. 1967. A MATHAMATICAL MODEL FOR TRIBOLIUM CONFUSUM POPULATIONS. ECOLOGY 48:290-293.

254 TEBO, L.B., JR. 1955. EFFECTS OF SILTATION, RESULTING FROM IMPROPER LOGGING, ON THE BOTTOM FAUNA OF A SMALL TROUT STREAM IN THE SOUTHERN APPALACHIANS. PROG. FISH-CULT. 17:64-70.--SILT LOADS OF 261 TO 390 PPM CREATED BY DRAGGING LOGS OVER THE GROUND NEAR THE STREAM REDUCED BENTHIC POPULATIONS TO 25% OF THEIR NORMAL DENSITY. SILT DEPOSITION. SUSPENDED SEDIMENT. TURBIDITY. BENTHIC MACROINVERTEBRATES.

255 TRAUTMAN, M.B. 1933. THE GENERAL EFFECTS OF POLLUTION ON OHIO FISH LIFE. TRANS. AM. FISH. SOC. 63:69-72.--DISCUSSES SUSPENDED AND DEPOSITED SILT IN RELATION TO CHANGES IN THE FISH FAUNA OF OHIO RIVERS. SILT DEPOSITION. SUSPENDED SEDIMENT. TURBIDITY. FISH.

256 TRAUTMAN, M.B. 1939. THE EFFECTS OF MANMADE MODIFICATIONS ON THE FISH FAUNA IN LOST AND GORDON CREEKS, OHIO, BETWEEN 1887-1938. OHIO J. SCI. 39:275-282.--DISCUSSES SUSPENDED SILT IN RELATION TO FISH FAUNAL CHANGES IN LOST AND GORDON CREEKS. SILT DEPOSITION. SUSPENDED SEDIMENT. TURBIDITY. FISH.

257 TRAUTMAN, M.B. 1957. THE FISHES OF OHIO. OHIO ST. UNIV. PRESS, COLUMBUS, OHIO.--DISCUSSES TOLERANCE OF OHIO FISH SPECIES TO SUSPENDED AND DEPOSITED SILT. SILT DEPOSITION. SUSPENDED SEDIMENT. TURBIDITY. FISH.

258 *USHER, M.B. 1969 A MATRIX MODEL FOR FOREST MANAGEMENT. BIOMETRICS 25:309-315.

259 *USHER, M.B., AND M.H. WILLIAMSON. 1970. A DETERMINISTIC MATRIX MODEL FOR HANDLING THE BIRTH, DEATH, AND MIGRATION PROCESSES OF SPATIALLY DISTRIBUTED POPULATIONS. BIOMETRICS. 26:1-12.

260 VAN OOSTEN, J. 1948. TURBIDITY AS A FACTOR IN THE DECLINE OF GREAT LAKES FISHES WITH SPECIAL REFERENCE TO LAKE ERIE. TRANS. AM. FISH. SOC. 75:281-322.--ANY GENERAL DECLINE IN THE LAKE ERIE FISHES CANNOT BE ATTRIBUTED TO INCREASED TURBIDITIES AS THE SAME FISHES WHICH INHABIT CLEAR WATERS OF THE GREAT LAKES HAVE ALSO DECLINED. TURBIDITY VALUES HAVE ACTUALLY DECREASED AND MORE FOOD IS AVAILABLE IN TURBID REGIONS OF THE LAKE. TURBIDITY DATA IN PPM. FISH DATA AS DENSITY AND BIOMASS BY YEAR CLASS. TURBIDITY. SALMONIDAE. PERCIDAE. ICTALURIDAE. CYPRINIDAE. ZOOPLANKTON. PHYTOPLANKTON.

261 VERDUIN, J. 1954. PHYTOPLANKTON AND TURBIDITY IN WESTERN LAKE ERIE. ECOLOGY 35:550-561.--DISCUSSES TURBIDITY AS RELATED TO LIGHT PENETRATION AND PRIMARY PRODUCTIVITY. TURBIDITY DATA AS DEPTH OF LIGHT PENETRATION. PHYTOPLANKTON STANDING CROP IN MM3/L. SUSPENDED SEDIMENT. TURBIDITY. PHYTOPLANKTON.

262 VINYARD, G.L., AND W.J. O'BRIEN. 1976. EFFECTS OF LIGHT AND TURBIDITY ON THE REACTIVE DISTANCE OF BLUEGILL (LEPOMIS MACROCHIRUS). J. FISH. RES. BOARD CAN. 33:2845-2849.--BOTH INCREASED TURBIDITY AND REDUCED ILLUMINATION CAUSED SUBSTANTIAL REDUCTION IN THE REACTIVE DISTANCE OF BLUEGILL TO VARIOUS SIZES OF DAPHNIA PULEX PREY, PARTICULARLY FOR LARGE PREY. TURBIDITY DATA IN JTU'S. TURBIDITY. CENTRARCHIDAE. ZOOPLANKTON.

263 WALBURG, C.H., D. MARTIN, W.R. NELSON, AND F.C. JUNE. 1977. LIFE HISTORY OF MISSOURI RIVER MAIN STEM RESERVOIR FISHES. PROG. REP. 84434-902, U.S. FISH WILDL. SERV., DEPT. POP. ECOL. (ABSTR.).--SILTATION IN MISSOURI RIVER MAIN STEM RESERVOIRS HAS REDUCED FISH SPAWNING AND NURSERY AREAS. AUTHORS PROPOSE TO RELATE SILTATION AND TURBIDITY TO WALLEYE AND SHAD ABUNDANCE, GROWTH AND MORTALITY. SILT DEPOSITION. SUSPENDED SEDIMENT. CLUPEIDAE. PERCIDAE.

264 WALLEN, I.E. 1951. THE DIRECT EFFECT OF TURBIDITY ON FISHES. OKLA. AGR. MECH. COLL., BULL. 48:1-27.--TESTS WERE MADE TO DETERMINE THE DIRECT EFFECT OF MONTMORILLONITE CLAY ON 16 SPECIES OF FISH. BEHAVIORAL REACTIONS APPEARED AT 20,000 PPM. ALL SPECIES ENDURED EXPOSURES TO MORE THAN 100,000 PPM FOR A WEEK OR LONGER, BUT DIED WITHIN 15 MINUTES TO TWO HOURS AT CONCENTRATIONS OF 175,000 TO 225,000 PPM. FISH WHICH SUCCUMBED TO TURBIDITY HAD OPERCULAR CAVITIES AND GILL FILAMENTS CLOGGED WITH SEDIMENT PARTICLES. SUSPENDED SEDIMENT. TURBIDITY. CYPRINIDAE. ICTALURIDAE. UMBRIDAE. CYPRINODONTIDAE. POECILIIDAE. CENTRARCHIDAE.

265 WANG, J.C.S., AND T.R. TATHAM. 1971. A STUDY OF THE RELATIONSHIP OF SUSPENDED SEDIMENTS AND FISH EGGS IN THE UPPER CHESAPEAKE BAY AND ITS CONTIGUOUS WATERS, WITH SPECIAL REFERENCE TO STRIPED BASS. ICHTHYOL. ASSOC., MIDDLETOWN, DEL.--STUDY REPORTS NO CHANGE IN ABSOLUTE HATCHING RATE OF EGGS OF YELLOW PERCH, WALLEYE, ALEWIFE, STRIPED BASS AND AMERICAN SHAD FROM LABORATORY EXPOSURE TO SUSPENDED SEDIMENT OF 25 TO 500 MG/L. CONCENTRATIONS OF 100 TO 500 MG/L DELAYED HATCHING OF EGGS OF YELLOW PERCH BY 6-12 HOURS, WHITE PERCH AND STRIPED BASS 4-6 HOURS. AND AMERICAN SHAD BY 4 HOURS. THE DELAY WAS ATTRIBUTED TO REDUCED LIGHT OR OXYGEN FROM DEPOSITION OF SEDIMENT ON THE EGGS. SILT DEPOSITION. SUSPENDED SEDIMENT. TURBIDITY. CLUPEIDAE. PERCICHTHYIDAE. PERCIDAE.

266 WARD, H.B. 1938. PLACER MINING ON THE ROGUE RIVER OREGON, IN ITS RELATION TO THE FISHING IN THAT STREAM. OREGON DEP. GEOL. MINERAL INDUST., BULL. 10:4-25.--SUSPENDED AND DEPOSITED SILT FROM PLACER MINE RUNOFF DID NOT ADVERSELY AFFECT SALMONID ADULTS. FRY, NESTS OR EGGS, AND BENTHIC ORGANISMS. SEDIMENT DATA IN PPM. INFORMATION ON FISH AND BENTHOS DENSITIES IS QUALITATIVE. SILT DEPOSITION. SUSPENDED SEDIMENT. TURBIDITY. SALMONIDAE. BENTHIC MACROINVERTEBRATES.

267 WARD, J.V., AND J.A. STANFORD. 1980. ECOLOGICAL FACTORS CONTROLLING ZOOBENTHOS WITH EMPHASIS ON THERMAL MODIFICATION OF REGULATED STREAMS. PP. 35-55 IN J.V. WARD AND J.A. STANFORD, EDS. THE ECOLOGY OF REGULATED STREAMS. PLENUM PUBL. CO., N.Y., N.Y.--RESERVOIR CLARIFICATION REDUCES DOWNSTREAM TURBIDITY AND MAY CAUSE REDUCED POPULATIONS OF FILTERFEEDERS. SUBMERGED ANGIOSPERMS AND BENTHIC ALGAE ARE USUALLY ENHANCED BY DECREASED TURBIDITY. TURBIDITY. SILT DEPOSITION. PHYTOPLANKTON. MACROPHYTES. BENTHIC MACROINVERTEBRATES.

268 WATERS, T.F. 1976. EFFECTS OF SILT AND TURBIDITY FROM AGRICULTURAL DRAINAGE ON BENTHIC INVERTEBRATES IN STREAMS IN WESTERN MINNESOTA. PROG. REP. B-120-MINN., OFF. WATER RES. TECH., U.S. DEPT. OF INTER. (ABSTR.).--ONGOING PROJECT INVOLVING BOTH FIELD AND LABORATORY PROCEDURES TO STUDY THE EFFECTS OF SUSPENDED SILT ON STREAM BENTHOS. NO DATA OR RESULTS GIVEN. SILT DEPOSITION. SUSPENDED SEDIMENT. TURBIDITY. BENTHIC MACROINVERTEBRATES.

269 WEBER, W.J. 1978. ADSORPTION OF POLYCHLORINATED BIPHENYLS ON SUSPENDED SOLIDS AND THEIR DISTRIBUTION AND DIFFERENTIAL ACCUMULATION IN RIVERS, HARBORS, AND LAKES. PROG. REP. 341 (NOAA/EAO), NAT. OCEAN. ATM. ADMIN, WASH., D.C. (ABSTR.).--PRESENTS QUANTITATIVE DATA REGARDING THE ASSOCIATION OF PCB'S WITH SUSPENDED SEDIMENT. DISCUSSES IMPACTS ON THE AQUATIC FOOD WEB AND FISHERIES. SUSPENDED SEDIMENT. TURBIDITY. BENTHIC MACROINVERTEBRATES. FISH.

270 *WESTLAKE, D.F. 1966. THE LIGHT CLIMATE FOR PLANTS IN RIVERS. PP. 99-119 IN R. PP. 99-119 IN R. BAINBRIDGE, G.C. EVANS AND O. RACKMAN (EDS.), LIGHT AS AN ECOLOGICAL FACTOR. AINBRIDGE, G.C. EVANS AND O. RACKMAN(EDS.), LIGHT AS

271 WESTLAKE, D.F. 1975. MACROPHYTES. PP. 105-155 IN B.A. WHITTON, ED. RIVER ECOLOGY. UNIV. CALF. PRESS, BERKELEY.--THERE IS LOWER BIOMASS OF MACROPHYTES IN TURBID WATERS DUE TO INSUFFICIENT LIGHT. SILT DEPOSITION. SUSPENDED SEDIMENT. TURBIDITY. MACROPHYTES.

272 *WETZEL, R.G. 1975. LIMNOLOGY. W.B. SANDERS CO., PHILADELPHIA.

273 WETZEL, R.G. AND D.L. MCGREGOR. 1968. AXENIC CULTURE AND NUTRITIONAL STUDIES OF AQUATIC MACROPHYTES. AM. MIDL. NAT. 80:52-63.--TURBIDITY RELATED LOW LIGHT INTENSITY INHIBITS GERMINATION OF NAJAS FLEXILIS AND CHARA. SUSPENDED SEDIMENT. TURBIDITY. MACROPHYTE.

274 WHITTON, B.A. 1975. ALGAE. PP. 81-105 IN B.A. WHITTON, ED. RIVER ECOLOGY. UNIV. CALF. PRESS, BERKELEY.--DISCUSSES SUSPENDED AND DEPOSITED SEDIMENT IN RIVERS AS A SURFACE FOR ALGAL ATTACHMENT AND AS RELATED TO LIGHT PENETRATION. SILT DEPOSITION. SUSPENDED SEDIMENT. TURBIDITY. PHYTOPLANKTON. PERIPHYTON.

275 WICKETT, W.P. 1954. THE OXYGEN SUPPLY TO SALMON EGGS IN SPAWNING BEDS. J. FISH. RES. BOARD CAN. 11:933-953.--DISCUSSES RELATIONSHIP BETWEEN THE AMOUNT OF SEDIMENT DEPOSITION AND OXYGEN AVAILABILITY IN SALMON REDDS. SILT DEPOSITION. SUSPENDED SEDIMENT. TURBIDITY. SALMONIDAE.

276 *WILHM, J.L. 1965. SPECIES DIVERSITY OF BENTHIC MACROINVERTEBRATES IN A STREAM RECEIVING DOMESTIC AND OIL REFINERY EFFLUENTS. PH.D. DISSERTATION. OKLAHOMA STATE UNIVERSITY, STILLWATER.

277 *WILHM, J.L. 1970. RANGE OF DIVERSITY INDICES IN BENTHIC MACROINVERTEBRATE POPULATIONS. J. WATER POLLUT. CONTR. FED. 42:R221-R224.

278 *WILHM, J.L., AND T.C. DORRIS. 1968. BIOLOGICAL PARAMETERS FOR WATER QUALITY CRITERIA. BIOSCIENCE 18:477-480.

279 WILLIAMS, R., AND M.F. HARCUP. 1974. THE FISH POPULATIONS OF AN INDUSTRIAL RIVER IN SOUTH WALES, UNITED KINGDOM. J. FISH. BIOL. 6:395-414.--SPORADICALLY HIGH LEVELS OF SUSPENDED SOLIDS FROM COAL RESIDUES LIMITED BROWN TROUT SPAWNING AREAS. TROUT PRODUCED IN THE STREAM SHOWED POOR GROWTH. SEDIMENT DATA IN MG/L. GIVES LENGTH, WEIGHT, AGE, FECUNITY, DENSITY, BIOMASS AND RECRUITMENT FOR EIGHT SPECIES OF FISH. SILT DEPOSITION. SUSPENDED SEDIMENT. TURBIDITY. SALMONIDAE. CYPRINIDAE. COTTIDAE. GASTEROSTEIDAE. ANGUILLIADE.

280 WILSON, J.N. 1957. EFFECTS OF TURBIDITY AND SILT ON AQUATIC LIFE. PP. 235-239 IN C.M. TARZWELL, ED. BIOLOGICAL PROBLEMS IN WATER POLLUTION. U.S. DEPT. HEW, CINCINNATI, OHIO.--SUMMARIZES SOME OF THE EARLY (PRE-1954) LITERATURE ON THE EFFECTS OF TURBIDITY AND SILT ON FRESHWATER ORGANISMS. SILT DEPOSITION. SUSPENDED SEDIMENT. TURBIDITY. FISH. BENTHIC MACROINVERTEBRATES.

281 WINNER, J.M. 1975. ZOOPLANKTON. PP. 155-169 IN B.A. WHITTON, ED. RIVER ECOLOGY. UNIV. CALF. PRESS, BERKELEY.--TURBIDITY FROM AGRICULTURAL RUNOFF INDIRECTLY AFFECTS ZOOPLANKTON PRODUCTIVITY, INHIBITING ALGAL PRODUCTION, WHICH ELIMINATES CERTAIN FILTER FEEDERS SUCH AS THE CLADOCERA AND COPEPODA, AND DIRECTLY BY INTERFERING WITH THE FEEDING PROCESS ITSELF. UNDER TURBID CONDITIONS SILT CAN ACCUMULATE IN THE DIGESTIVE TRACT OF CLADOCERA AND CAUSE THEM TO SINK. SUSPENDED SEDIMENT. TURBIDITY. PHYTOPLANKTON. ZOOPLANKTON.

282 WU, Y.F. 1931. A CONTRIBUTION TO THE BIOLOGY OF SIMULIUM (DIPTERA). PAP. MICH. ACAD. SCI. 13:543-599.--THE DISTRIBUTION OF SIMULIUM WAS DEPENDENT ON THE AMOUNT OF SILT IN THE WATER. SILT DEPOSITION. SUSPENDED SEDIMENT. BENTHIC MACROINVERTEBRATES.

283 WYNAROVICH, E. 1959. ERTBRUTUNG VON FISHEIREN IN SPRUHRAWN. ARCH. FISHCH. WISS. 13:179-189.--EUROPEAN PIKE-PERCH (LUCIOPERCA LUCIOPERCA) LAY THEIR EGGS ON SURFACES. HIGH EGG MORTALITY WAS ASSOCIATED WITH INCREASED SILTING. SILT DEPOSITION. PERCIDAE.

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Vaughn, Caryn C
Feasibility of using Rational Threshold Values to predict sediment impacts from Army training / by Caryn C. Vaughn, Gary D. Schnell, Robert E. Riggins. -- Champaign, Ill : Construction Engineering Research Laboratory ; available from NTIS, 1983.
54 p. (Technical report / Construction Engineering Research Laboratory ; N-153)

1. Sediment, suspended--mathematical models. 2. Military training camps. 3. Rational threshold values. I. Schnell, Gary D. II. Riggins, Robert E. III. Title. IV. Series: Technical report (Construction Engineering Research Laboratory); N-153.

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